POPULAR PHYSIOLOGY

TRALL

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POPULAR PHYSIOLOGY:

A Familiar Exposition

OF THE

STRUCTURES, FUNCTIONS, AND RELATIONS OF THE HUMAN SYSTEM.

AND THEIR

APPLICATION TO THE PRESERVATION OF HEALTH.

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PREFACE.

The object of this volume, which is partly a compilation from the author's larger works, is to present, with the usual Anatomical descriptions and illustrations, a more complete explanation and application of Physiology and Hygiene to the purposes of practical life, than is found in the numerous Physiologies for schools in the market. It is, therefore, intended to be specially adapted to the wants of families and schools.

FLORENCE HIGHTS, N. J. R. T. T.

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CONTENTS.

CHAPTER VIII.

CHAPTER IX.

CHAPTER X.

CHAPTER XI.

CHAPTER XII.

CHAPTER XIII.

CHAPTER XIV.

CHAPTER XV.

CHAPTER XVI.

POPULAR PHYSIOLOGY.

CHAPTER I.

MAN'S PLACE IN NATURE.

GEOLOGY and Genesis agree that the human being is the crowning work of the Almighty Architect; the Bible and science harmonize in placing man at the head of creation, as the production of Infinite Wisdom. Myriads of living organisms preceded him in the order of existence, and uncertain ages elapsed while the earth was being prepared for his habitation. Yet how transient his sojourn! Like a drop of water to the vast ocean is the duration of his existence here, compared with the long cycles of ages required to form the solid ground from the incandescent ether. Surely, this life cannot be all there is of beings so endowed with ever-unfolding faculties, so constituted with endless hopes, and so blessed with immortal aspirations.

FIG. 1.—MAN.

In the order of nature the greater always includes the less. Man embodies in his organization all the elements of all living things,

What is said of man's place in nature? What does man's organization embody?

and every power of every mind that has preceded him in the scale of being. He has all the vital properties of the plant, all the instincts of both plant and animal; and, in addition thereto, moral and intellectual powers peculiar to himself. He is not, therefore, a "higher animal." He is not an animal at all, but a human being. And when we analyze his mental endowments, and compare and contrast them with the highest animals, we shall see in what his humanity consists.

Whether the human family has proceeded from a single pair; whether there have been distinct creations for the different races; whether there has been a pre-Adamite man; whether man has developed according to a universal type; whether he originated in a special act of creative energy—these are problems we must yet leave with the scientists and theologians. Possibly we may eventually arrive at the demonstrated truth of some or all of these interesting questions. Meanwhile, our interest and our duty are plain enough. Whatever the truth may be it is best for us to understand it *whenever we can.* Let us, therefore, seek truth, honestly and sincerely, on these and on all other subjects. Let us make the best possible use of what we do know. Let us be charitable to others concerning all matters of opinion, and concede to them the same freedom of conscience and independence of judgment that we claim for ourselves. "Do unto others as you would have others do unto you," is a precept which, if universally recognized in practice, would change scientific controversies into earnest investigations, and substitute emulation in well-doing for religious disputations.

The doctrine of the "descent of man," which is just now the most prominent of the many debatable questions among the learned, would be divested of all its odium if Darwin and his disciples would change the phrase to "*ascent of man.*" This is what they really mean. And this is the philosophical truth. But in employing a misnomer, Darwinism has arrayed against the theory it has advanced an immense amount of honest prejudice and justifiable self-esteem. It is sufficiently humiliating to our reasonable pride to have *descended* from anything. It is quite bad enough to have degenerated from a higher human

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What are the unsolved problems respecting the human race? What is our duty concerning those problems? What is the golden rule of action?

being; but to ask us to admit that we have descended from the lower animals, is requiring too much of our poor, yet proud human nature.

But Darwinism, rightly explained, has nothing degrading nor disagreeable; nor is it at variance with the theory that human beings, in different parts of the world, have grown better or worse in different periods of history. Yet, as there are a hundred quarrels about words to one dispute about ideas, those who present new doctrines, or assume to be teachers, cannot be too explicit and unambiguous in technical terms.

Nothing can *descend* from anything lower than itself. It may descend *towards* it. But if the direction be from it, the movement must of necessity be upward. Whatever our origin may prove to be, our consolation and hope may be found in the fact that we are *higher than the animals*, though not higher animals; and as there is nothing in the visible creation higher than ourselves, our position ought to be satisfactory.

In realizing the grand truth that man has *ascended* from the animal kingdom, no matter how, to a higher plane of existence, and with peculiar endowments and attributes, as the animal ascended from the preceding vegetal kingdom, we recognize the law of progress. And we get rid of the debasing idea that we are the offspring of the gorilla or the monkey, and that the quadruped or the reptile are our progenitors. The animals below us have nothing to do with our parentage, because they have preceded us. We might as well call the plants the parents of the animals because they were first in the order of existence. It is development, not parentage, that we are to understand. It is *ascent* and not descent, that applies to humanity in its relation to the animal kingdom.

Every living organism, plant, animal, or man, is, in its processes of development and growth, but the unfolding of a primordial germ—a seed, or an egg. This fact presupposes a parental source, for "spontaneous generation" has not yet been proved. The seed, or egg, develops and grows according to fixed and invariable laws, requiring certain conditions of air, temperature and moisture, with certain elements which serve the purposes of food. If these conditions are imperfect, the devel-

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What is Darwinianism? Why has not man descended from the animals? How is man higher than the animals?

opment and growth will be abnormal. Excess or deficiency in any normal agency, or the introduction of non-usable or poisonous materials, disturb the "normal play of the functions;" and herein is the origin of disease. Vegetables feed on inorganic elements and atmospheric gases, which are deleterious to animals and man. Man and animals can only feed on organic matter, and require pure air and water, and food which contains no inorganic or chemical elements. If man breathes an impure atmosphere, drinks hard or stagnant water, and eats food mingled with impurities or inorganic elements of any kind, his health suffers accordingly, and his period of life is correspondingly abridged.

These considerations establish the principle that a life, to be healthy and enduring, must be in accordance with the laws of life. As our relations to all else in the universe are determinate and unalterable, these relations constituting the laws of our being, it follows that our best good, our greatest interest, and our highest happiness can only be found in harmony with, or obedience to, those laws. Every act in disobedience to organic law is a cause of suffering; it occasions disease and tends to premature death. Vitality can be expended, but it cannot be regained. How important, therefore, if we would live long in the land, or be useful and happy while we do live, that we understand the laws of the "fearfully and wonderfully made" machinery of life. The maxim that, "intensive life cannot be extensive," should be taught to every child in the primary school; nor can the child too soon learn the important lesson that all stimulation, whether in the shape of food, drink, or medicine, is abnormal, disease-producing, and wasteful of the unreplenishable fund of life. To nourish the body without stimulating it, is the essential problem that physiologists and medical teachers have generally misunderstood or disregarded. Indeed many of them teach the very opposite—that stimulation is invigorating and necessary.

What is understood by development? State some of the conditions of growth. Wherein is the origin of disease? On what do vegetables feed? What food do man and animals require? State some things injurious to health. In what consists our highest happiness? State an important maxim of life. What is the effect of stimulation?

CHAPTER II.

RACES OF MEN.*

THE division of the human family into races or classes, each distinguished by certain striking peculiarities in the shape of the head, and in the structure, color, and arrangement of the skin, hair, and eyes, though strictly belonging to the science of ethnology, is a subject constantly becoming more interesting to the physiologist, from its intimate connection with the development of men, and the improvement and advancement of humanity.

A classification of mankind into leading classes must, of course, involve distinctions purely arbitrary; for the races may be distinguished into two or twenty, or any number between, as the marks of difference are more or less prominent.

The division of Blumenbach, who makes five principal races, is as useful and satisfactory as any other can be. These are named the *Caucasian*, *Mongolian*, *Ethiopic*, *American*, and *Malay*.

Fig. 2.—CAUCASIAN RACE.

THE CAUCASIAN RACE.—The Caucasian race is remarkable for the highest physiological development, personal symmetry and beauty, and intellectual attainments. The chief families of this race are the *Caucasians proper*, and the *Germanic*, *Celtic*, *Arabian*, *Libyan*, *Nilotic*, and *Hindostanic* branches.

* The articles on "Races, Population, and Temperament," are copied substantially from "The Hydropathic Encyclopædia," a work recommended to all who desire to be well-informed in relation to the conditions of health, and the most successful methods of treating diseases.

What races of men are there? For what is the Caucasian remarkable? What are its chief families?

In this race the skin is generally fair, the hair fine and long, and of various colors, the skull large, rounded, and oval, and the forehead broad or prominent, large and elevated. The face is relatively small and well-proportioned, the nose arched, the chin full, and the teeth vertical.

In this variety or race of men we find the farthest remove from the animal in brain, features and hair, with a superiority of intellectual and moral power, love of the arts, science and poetry. The progress of the human family seems to be made wholly through this race.

THE MONGOLIAN RACE.—The Mongolian variety includes the *Mongol Tartars*, *Turks*, and the *Chinese* and *Polar* tribes, which inhabit a vast extent of the earth's surface, and constitute about half of the population of the globe. In physiological characteristics the Mongolians manifest considerable variety. The hair is black, long, and straight, the beard scanty, the skin commonly of an olive tint, the eyes black, the nose broad and short, the cheek-bones broad and flat, the skull oblong, but flattened, so as to give it a square appearance, and the forehead low.

In moral development this race is decidedly inferior; their intellectual powers are more imitative than inventive, and they possess but little strength and originality of mind.

Fig. 3.—MONGOLIAN RACE.

Fig. 4.—ETHIOPIC OR BLACK RACE.

THE ETHIOPIC RACE.—The *Negroes of Central Africa*, the *Caffres* and *Hottentots of South Africa*, the *Natives of Australia*,

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How is the Mongolian race distinguished? What tribes and nations does it include? How is the Ethiopic or black race distinguished? Who are its principal families?

and the *Islanders of the Indian Archipelago and the Pacific Ocean*, constitute the principal families of the Ethiopic or black race.

The black variety of mankind have complexions of jetty hue, black, woolly hair, eyes large, black, and prominent, nose broad and flat, thick lips, and wide mouth. The head is long from the ears back, and narrow; the forehead is low, narrow, and retreating; the cheek-bones prominent, the jaws and teeth projecting, and the chin small. A long, protruding heel, and a flat shinbone, often distinguish this variety.

In disposition they are easy, indolent, cheerful, fond of sensual pleasure, and lovers of children, fond of gaudy show, but very improvident. In intellect the race varies much, but the majority of its tribes are low in this respect. There are, however, many instances in which individuals of this race have exhibited respectable talent.

THE AMERICAN RACE.—The *Indian tribes*, or "*Red men*," who occupied originally nearly the whole of *North* and *South America*, south of the sixtieth degree of north latitude, constitute this variety.

Fig. 5.—AMERICAN RACE.

The people of this race vary considerably in complexion, but are mostly of a reddish-brown color. The hair is long, straight, and black, the beard deficient, the eyes black and deep set, brows prominent, forehead receding, prominent aquiline nose, high cheek-bones, small skull, rising high at the crown, and the back part flat, large mouth, hard, rough features, with fine, straight, symmetrical frames. They are averse to cultivation, and slow in acquiring knowledge, sedate, proud, restless, sly, revengeful, fond of war, and wholly destitute of maritime adventure, and are rapidly disappearing from the earth before the all-conquering march of the Caucasian.

THE MALAY RACE.—This variety of the human family inhabit *Borneo*, *Java*, the *Philippine Islands*, *New Zealand*, the *Polynesian Islands*, and a part of *Madagascar*.

How is the American race distinguished? Where is it found? What countries does the Malay race inhabit?

The Malays have tawny or dark brown skins, coarse, black hair, large mouth, broad, short noses, seeming as if broken at the root, projecting upper jaws, and protruding teeth. The forehead is broad and low, the crown of the head high. The moral character of the Malays is of an inferior order. They are active, ingenious, and fond of maritime pursuits, and exhibit considerable intellectual capacity. Yet this race is constantly giving way before European civilization, and has already disappeared from New Holland and Van Diemen's Land.

Fig. 6.—Malay Race.

If the opinion is correct that the stronger race continually overgrows all the rest, and gradually obliterates them from the earth, the Caucasians are surely destined eventually to "possess the land." The history of the whole human race thus far indicates that such is the order of nature.

Origin of the Races.—Whether the various races of men have each had separate origins, or whether they are descendants of a common pair, modified by habits of life, climate, and external conditions, my limits will not permit me to discuss. Dr. Pritchard, after a labored investigation, came to the conclusion of the original *unity* of the races of the human family. Other authors have examined the subject apparently as critically, and settled down upon the opinion of the original *diversity* of the races.

Dr. Carpenter remarks: "It is a question of great scientific interest, as well as one that considerably affects the mode in which we treat the races that differ from our own, whether they are all of *one* species; that is, descended from the *same* or from *similar* parentage, or whether they are to be regarded as *distinct species*, the first parents of the several races having had the same differences among themselves as those now exhibited by their descendants."

No doubt the question of the natural inferiority of a race or tribe of the family of mankind really *does* affect the manner in

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How is the Malay race distinguished? What is the unsolved problem with regard to the races?

which they are dealt with by their superiors, and materially modifies the state of their consciences in relation to the use or abuse of the weaker by the stronger; still this might makes no right, nor does this question furnish any reason why the more powerful race should maltreat the more feeble. I admit that the process of extermination is going on, according to the irreversible laws of nature, from the highest human being to the lowest animal. I believe that the stronger animals will exterminate the weaker, that man will eventually run out of existence the stronger animals, and that the superior tribe of the human family will finally obliterate all traces of the existence of all the others; still I cannot see in the operations of this law any reason for oppressing, or even for not striving for the development of all men, yes, of all animals, according to their capacities and conditions. So long as inferior men *do* exist, our duty to them is plain enough. No one pretends that we, the stronger, have any right to rid the earth of their presence by violence, or in any other way except that "ordained by Heaven." So far as Nature is concerned, she will see that her laws on the subject are faithfully executed, without our special interference. As far as the feebler races are capable of development and improvement, they are entitled to the same consideration as those who are more highly endowed in organization.

It is an encouraging indication of progress in the right direction that we have "Societies for the Prevention of Cruelty to Animals." Here is an ample field for the exercise of the better emotions of the human heart. But there is a nobler field beyond, and it is to be hoped that organizations for preventing cruelty to human beings will not be long wanted ; for there is more cruelty inflicted on human beings every day, than on all the animals in existence in a year. Besides, the susceptibilities of animals to pain is insignificant compared with that of human beings. The higher the organization the greater is its capacity for happiness or misery.

What is the tendency of strong and weak races? What is our duty to inferior races?

CHAPTER III.

TEMPERAMENTS.

By temperament is understood a disproportionate development of some organ, structure or system of organs. The ancients distinguished four temperaments, the sanguine, phlegmatic, lymphatic and melancholic, based on the predominance of the four supposed humors, blood, lymph, yellow bile and black bile, each of these being caused by the prevalence of some one of the four supposed elements—fire, air, water and earth. The modern classification usually adopted by medical writers is into

Fig. 7.—Nervous Temperament.
McDonald Clark.

Fig. 8.—Sanguine Temperament.
Thomas Moore.

nervous, *sanguine*, *bilious* and *lymphatic*, as the cerebral, the circulating, the muscular or the digestive system seem to predominate.

The nervous temperament (Fig. 7) when well-marked, is mani-

What do you understand by temperament? What was the ancient doctrine of temperaments? What is the modern classification? What is the latest division? What is the nervous temperament?

fested by a large head, delicate or sharp features, small bones and muscles, and angular points of the body.

The sanguine temperament, sometimes called the *arterial* (Fig. 8), is known by broad shoulders, florid complexion, blue eyes, light, sandy or brown hair, and a general smoothness of form and features.

The bilious temperament (Fig. 9) is denoted by large, full muscles, swelling veins, dark hair and eyes, and dark, brown or yellow complexion.

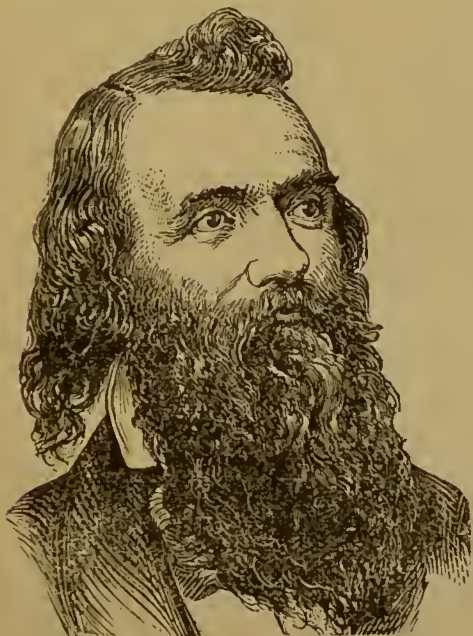

FIG. 9.—BILIOUS TEMPERAMENT.
D. C. MCCOLLUM.

FIG. 10.—LYMPHATIC TEMPERAMENT.
HON. WM. MAULE, M. P., OF PANMURE.

The lymphatic temperament (Fig. 10) is denoted by a general fullness or rotundity of the body, dull, pale appearance of the skin, and a disposition inclining to quietude if not indolence.

The nervous and sanguine are the *active*, while the bilious and lymphatic are the torpid temperaments, hence, when the cerebral and circulating systems are both predominant over the muscular and digestive systems, the person has the organization adapted to the highest manifestations of mental activity and sensibility; while, if both the muscular and digestive organs predominate the character will be sluggish, the body indolent and the mind dull.

What is the sanguine temperament? Bilious? Lymphatic? What is the sanguine temperament sometimes called? What is the active temperament?

But a more convenient, more practical and equally scientific arrangement of temperament—a division now adopted by most phrenologists—is into the *motive*, *vital* and *mental*. The motive temperament means a predominance of the moving machinery—the muscles and bones; the vital is due to predominance of the digestive apparatus, and the mental to the predominance of the brain organ. The motive temperament is favorable to strong action, the vital to good nutrition, and the mental to intense thinking and feeling.

Fig. 12.—Zadoc Pratt.

In treating of temperaments most authors confuse the subject by inaccuracy of language. They are in the habit of assigning two or more temperaments to the same individual; and they speak of a combination of temperaments, and of a harmonious or balanced temperament. Such language is not scientifically correct. No person can have more than one temperament, for the reason that the most prominently-developed organ, structure or apparatus constitutes the temperament. When, therefore, authors mention two or more temperaments, or a combination of temperaments, we are only to understand the relative development of the various organs or structures. A "balanced temperament" is no temperament at all, because there is no disproportionate development. The proper phrase in this case is balanced structural development, or harmonious organization. If a person is marked on a phrenological chart as having the nervous temperament 6, the sanguine 5, the bilious 4 and the lymphatic 3, the meaning is that

What is the motive temperament? Vital? Mental? To what are those temperaments respectively conducive? Can an individual have several temperaments?

he is of the nervous temperament, because the brain preponderates, and that the circulating, the muscular and osseous and digestive systems are developed in the ratio indicated by the figures.

THE MOTIVE TEMPERAMENT.—This is well represented in the cuts of Zadoc Pratt and the mother of Rev. John Wesley (Figs. 11 and 12).

FIG. 12.—MRS. WESLEY.

In the motive temperament the bones are large and broad, and the muscles full, dense and strong. The person is said to be *sinewy*. The figure is usually tall, the neck and face long, cheek bones high, shoulders broad and the chest full. The complexion varies, but the hair is strong and abundant. The features are strongly marked, and in extreme cases the expression is harsh and rigid, even when the disposition is kind and philanthropic. The whole organization seems especially constituted for bodily activity; and persons of this temperament are inclined to be industrious, persistent in their vocations, constant in friendship, energetic and ambitious.

THE VITAL TEMPERAMENT.—There are few better illustrations of the vital temperament than Luther, the great reformer,

What are the peculiarities of the motive temperament? What characters represent it? What tissues represent the temperaments respectively?

FIG. 13.—MARTIN LUTHER.

and Miss Braddon, the sensation novelist (Figs. 13 and 14).

The vital temperament marked by breadth and roundness of body. The chest is large, abdomen full, limbs plump, and hands and feet relatively small. The neck is short and thick, the features smooth, and the expression generally mirthful. Persons who have this temperament large are disposed to be active, both bodily and mentally; they love excitement, enjoy athletic amusements, but are adverse to hard continuous labor. In disposition they are genial and amiable, but inclined to be impulsive and versatile.

FIG. 14.—MARY ELIZABETH BRADDON.

THE MENTAL TEMPERAMENT. — As the brain is the organ of mind, its disproportionate development must of course constitute the mental temperament. It is well illustrated in Poe, the poet, and Ritchie, the actress (Figs. 15 and 17).

In the mental temperament the frame is slight, and the head relatively large; the

What are the peculiarities of the vital temperament? Of the mental? What characters represent each? What temperament is most conducive to muscular activity? What to mental power? What to good digestion?

forehead is high, face inclined to paleness, eyes light and expressive, features delicate, neck slender, chest small or only

FIG. 15.—EDGAR A. POE.

FIG. 16.—ANNA C. M. RITCHIE.

moderately full, and hair soft and fine. The thoughts are rapid, senses acute, imagination lively, and the moral emotions keen.

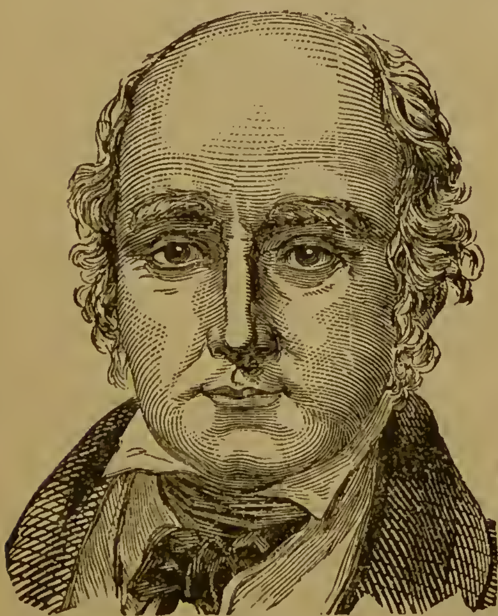

FIG. 17.—SIR JOHN FRANKLIN.

FIG. 18.—MADAME DE STAEL.

BALANCED TEMPERAMENT.—Very few persons better illustrate what is called the harmonious temperament, and what is prop-

erly termed the equable development, than Franklin the navi gator, and De Stael the philosopher (Figs. 17 and 18).

It is difficult to indicate the character of a harmonious devel

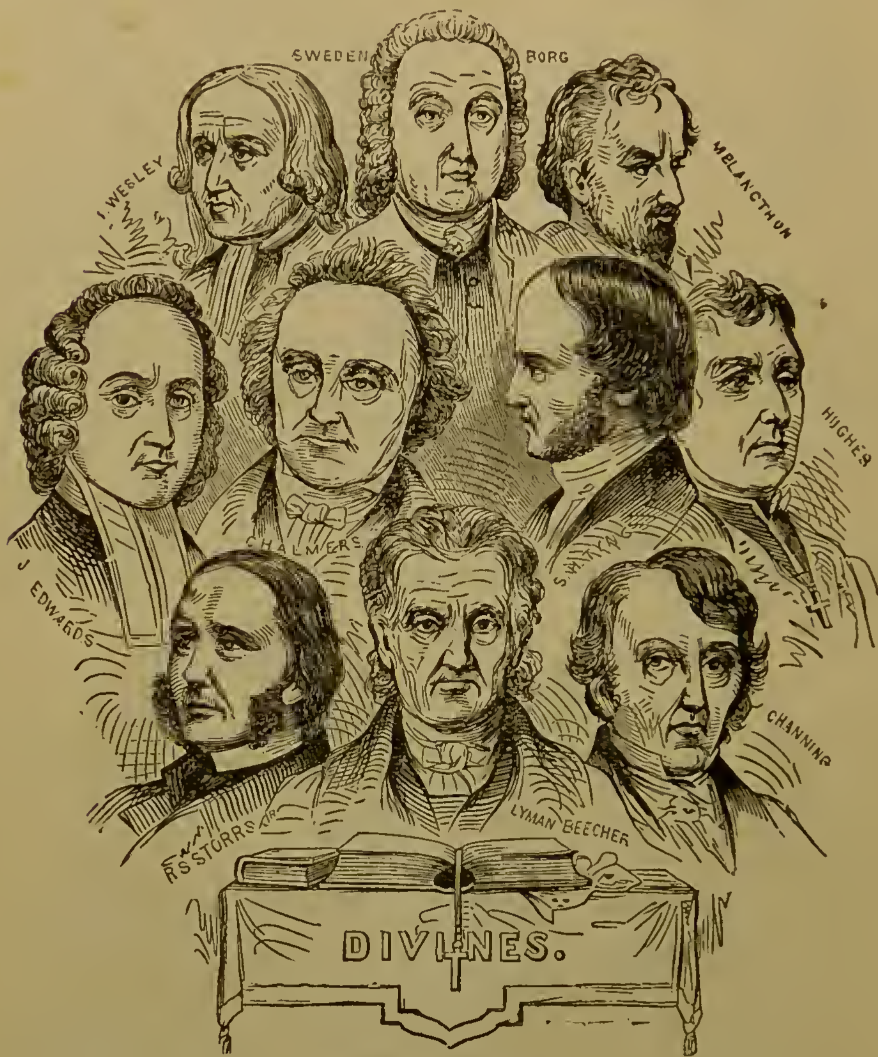

FIG. 19.—DIVINES.

opment. It is simply normal. Scientifically speaking, it has all character or no character. It has the best adjustment of all the parts, and under normal influences, is the best possible organization. But, under temptation or adverse circumstances,

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What is balanced temperament? What characters represent it? Why is a harmonious structural development inconsistent with temperament?

it is as liable to err in one direction as another. Hence, the future of all persons of this temperament depends on education, and suggests the importance of that wisest of all the sayings of wise men, "Train up a child in the way it should go."

In the preceding group of the heads of ten distinguished divines, some of whom are still living, the reader will readily recognize, and may profitably study each of the temperaments —motive, vital and mental—and their so-called combinations.

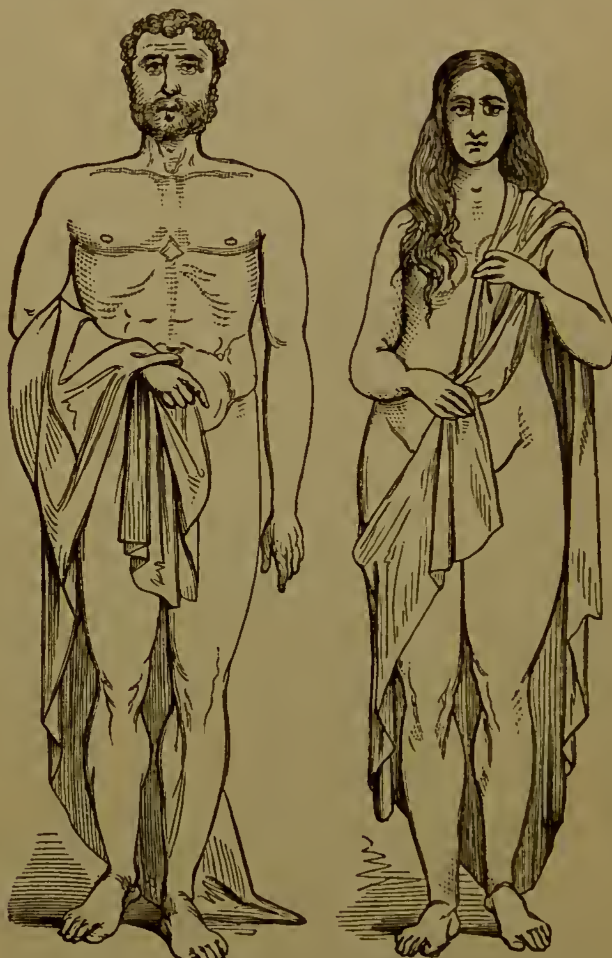
Much importance has been justly attached to the subject of temperament, both as respects the training of children and the education of adults, and the selection of companions for life in the matrimonial relation. Respecting physical and mental training there is much error, not only in our system of common-school education, but also in vocations and habits of life. Children who are weak in body often take precociously to books, and the early indications of mental talent are often treated with a forcing or hot-house culture, to the utter ruin of the bodily constitution; while children who manifest vigorous muscles are put to the exercises or business pursuits which aggravate the disproportion between mind and body, and produce an adult with a strong body and imbecile mind. The proper application of the doctrine of temperaments reverses this custom. The feebler parts of the organism should be most assiduously trained. A harmonious organization should always be aimed at in the rearing of children and education of youth. There will always be unbalanced conditions enough; and when the child has attained the vigorous development of full-rounded manhood or womanhood, there will be time enough to cultivate special talents. In this manner only can genius be placed on an enduring basis, and extraordinary original capacity be rendered safe to its possessor and most useful to mankind.

The temperament of a child should be carefully studied and judiciously managed from the moment it begins to walk and talk. If the temperament be decidedly motive, its mind should be frequently exercised with pictures and such toys as best serve the purpose of object-teaching; leaving it to exercise its muscular system at will in any proper plays or amusements.

How should children be trained with regard to temperament? What organs and structures need most exercise?

If the temperament be strongly vital, care should be taken that the mental and muscular exercises are properly balanced.

But the tendency of civilization is to develop the nervous temperament at the expense of the vital, producing a race of *educated imbeciles*, or knowing minds in unsound bodies—theoretically intelligent, but practically useless. Children who manifest a largely mental temperament should have little to do with primary schools as they are usually conducted. They should



FIGS. 20 AND 21.—WELL-BALANCED ORGANIZATION.

not go to such schools at all until seven or eight years of age, and then not be confined to them more than one or at most two hours. Such children—girls as well as boys—should be encour-

What children should have little to do with books? What habits are corrective of an excessive nervous temperament?

aged to work or play much out of doors, breathing the pure air and developing the vital organs, while book-education should be the incident, not the habit; the avocation, not the vocation. Especially should they be guarded against the sensational literature and trashy novels that deluge the land, perverting the intellect and corrupting the morals, as destructively to the whole mental nature as are the effects of alcohol and tobacco on the vital organism.

In the selection of conjugial partners, some authors advocate the rule of similarity, and others that of diversity of temperaments ; and it has been most absurdly pretended by some writers on human temperaments, that two perfectly harmonious temperaments are constitutionally incompatible, indeed, "physiologically incestuous." The teachings of nature, however, as manifested in the history of all the races of men, and as illustrated throughout the whole animal kingdom, are not difficult to understand.

Vital laws are the same everywhere. Most farmers very well know that, if he would have the most desirable crops he must plant the best quality of seed. And if he raises animals to take the premiums at the fairs, he selects the best stock, and attends carefully to all hygienic conditions during the period of growth. Food, air, water, temperature, exercise, and shelter are sedulously adapted to their needs. And the result is, animals of "pure blood," "high type," symmetrical, beautiful, perfect. So it would be with human beings were the laws of life and the conditions of health as carefully applied to them.

No agriculturist would hesitate to propagate, nor would any amateur stock-raiser hesitate to breed from parents whose temperaments were "balanced," or "harmonious," provided both were healthy, vigorous and well-developed.

A young man and a young woman, personally agreeable to each other, having each a harmonious organization, are certainly well-mated. Nor are considerable excesses or deficiencies in certain mental qualities or physical powers seriously objectionable, unless both parties have precisely the same excesses or deficiencies. If both are abnormal in the same direction the

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How is temperament applicable to the marriage relation? What is the first condition for having perfect living beings?

offspring will inevitably suffer; whereas, if one is full and large in constitutional endowment, wherein the other is small or greatly deficient, the tendency to a greatly unbalanced organization in the offspring is corrected. This whole matter of marrying according to temperament is, therefore, reduced to two simple rules. 1. Good health. 2. The avoidance of similar excesses or deficiences. With these rules in mind, the tall and short, fat and lean, blonde or brunette, may marry each other, or may marry temperaments and qualities like their own, with no apprehension of evil consequences; but, on the contrary, assured that, if their lives are in harmony with the laws of their being, their union will be blessed, and "the world will be the better for it."

The figures 20 and 21 exhibit the "balanced temperament," or harmoniously developed organization of the male and female forms.

CHAPTER IV.

BODILY POSITIONS.

A SINGLE glance at the situation of the various organs of the body, with respect to each other and to the bony skeleton, shows the importance of maintaining under all circumstances, the normal position. Erectitude is one of the most obvious laws of the vital machinery, yet almost every one is crooked. "Blessed are the upright" physically as well as morally.

Each structure and organ is provided with all the room necessary for its functional purposes, but no more. Nature is a rigid economist. She never wastes. She provides the machinery of life, and the conditions for its normal operation. Obey the law and live, disobey and die—these are her irrepealable mandates. The vital organs have definite relations to everything in the universe. Observe and conform to these relations and be well ; disregard them and suffer. Such is the stern teaching of Nature's volume. But it is also benevolent. If laws can be disregarded with impunity they are practically annulled, and exist in vain. Nature commits no error in the enactment of law, and provides no remedies for their infraction. Suffering is inevitable so long as we act in disobedience to the laws inherent in the vital organism. Unless this were so we could never learn to obey the laws. Experience may be a dear school. The penalties for transgression may be terrible. But neither is too costly or severe until it teaches us the greatest practical truth that the human mind is capable of comprehending—that all good is in the line of obedience to organic law, and all evil in opposition thereto.

"Cease to do evil and learn to do well" in all things, is the divine philosophy, and applicable to every department of human life. In few things are human beings more prone to do

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What is an important law of the vital machinery ? How is all good attainable . How does all evil result ?

evil and more regardless of all health considerations than in respect to bodily positions.

"Just as the twig is bent the tree 's inclined."

A great majority of children in our primary schools become more or less abnormally inclined in manhood, because they are bent out of shape in childhood by unhygienic seats and benches.

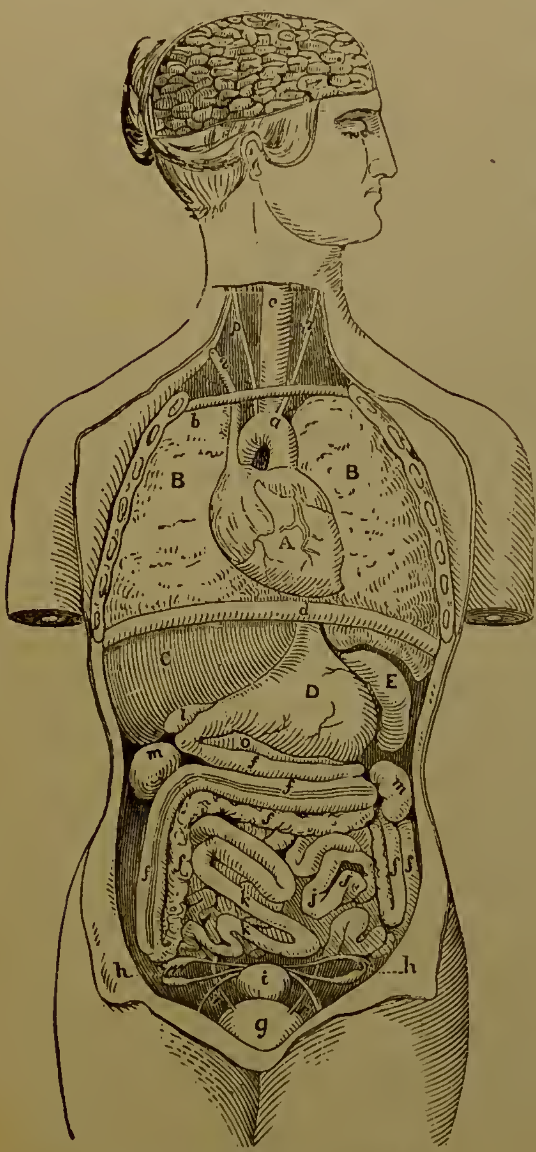

Fig. 23.—Internal Viscera.

In the cut (Fig. 23) are seen the situation and relations of the principal internal organs of the body.

The important lesson deducible from the illustration before us is, that in all of our exercises, active or passive, we should maintain the normal positions of the organs. In lying, sitting, standing, walking, running, working or playing, use the joints, and never bend or compress any other organ, part or structure.

It is evident that, if the body is habitually bent so as to approximate the heart, A, and stomach, D, or if the chest is restricted by lacing, so as to lessen the diameter of the chest in the region of the diaphragm, *d*, every organ of the thoracic and abdominal cavity is more or less compressed, and most of them actually displaced.

What is a great error in primary schools? What lesson is taught by the relations of the viscera? What is the rule for bending the body?

The horrid effects of tight-lacing (quite as ruinous to young ladies as tobacco-using is to young men), or of lacing at all, and of binding the clothing around the hips, instead of suspending it from the shoulders, can never be fully realized without a thorough education in anatomy and physiology. And if the illustrations here presented should effect the needed reform in fashionable dress, the resulting health and happiness to the human race would be incalculable; for the health of the mothers of each generation determines, in a very large measure, the vital stamina of the next.

It is obvious that, if the diameter of the chest, at its lower and broader part, is diminished by lacing, or any other cause, to the extent of one-fourth or one-half, the lungs, B, B, are pressed in towards the heart, A, the lower ribs are drawn together and press on the liver, C, and spleen, E, while the abdominal organs are pressed downward on the pelvic viscera. The stomach, B, is compressed in its transverse diameter; both the stomach, upper intestines and liver are pressed downward on the kidneys, M, M, and on the lower portions of the bowels (the intestinal tube is denoted by the letters *f*, *j* and *k*), while the bowels are crowded down on the uterus, *i*, and bladder, *g*. Thus every vital organ is either functionally obstructed or mechanically disordered, and disease, more or less aggravated, the condition of all. In *post-mortem* examinations the liver has been found deeply indented by the constant and prolonged pressure of the ribs, in consequence of tight-lacing.

The brain-organ, protected by a bony inclosure, has not yet been distorted externally by the contrivances of milliners and mantua-makers; but, lacing the chest, by interrupting the circulation of the blood, prevents its free return from the vessels of the brain, and so permanent congestion of that organ, with constant liability to headache, vertigo or worse affections, becomes a "second nature." And this condition is often aggravated by heavy water-falls, chignons and other ridiculous head-gear.

The vital resources of every person, and all available powers of mind and body, are measurable by the respiration. Pre-

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How should clothing be suspended? How is the brain affected by improper dress? How is the available vitality to be measured?

cisely as the breathing is lessened the length of life is shortened; not only this, but life is rendered correspondingly useless and miserable while it does exist.

It is impossible for any child, whose mother has diminished her breathing capacity by lacing, to have a sound and vigor-

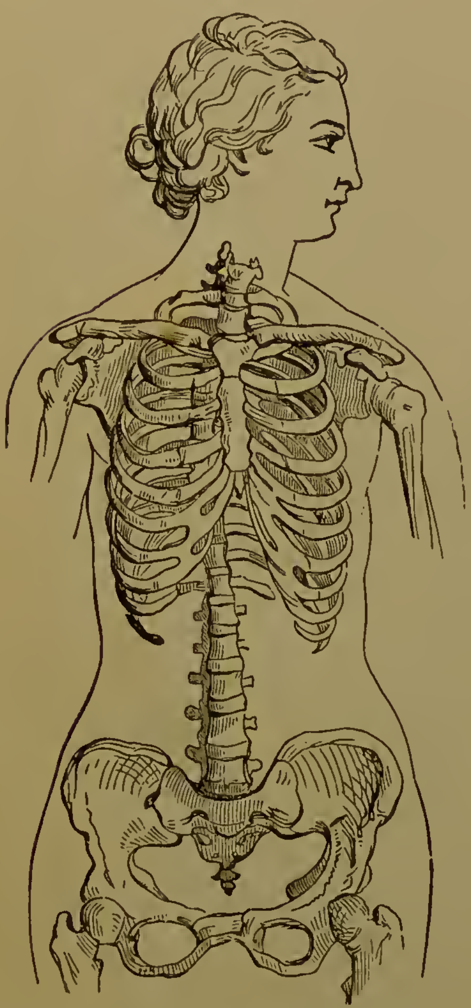

FIG. 24.—ANTERIOR VIEW OF THORAX IN THE VENUS OF MEDICIS.

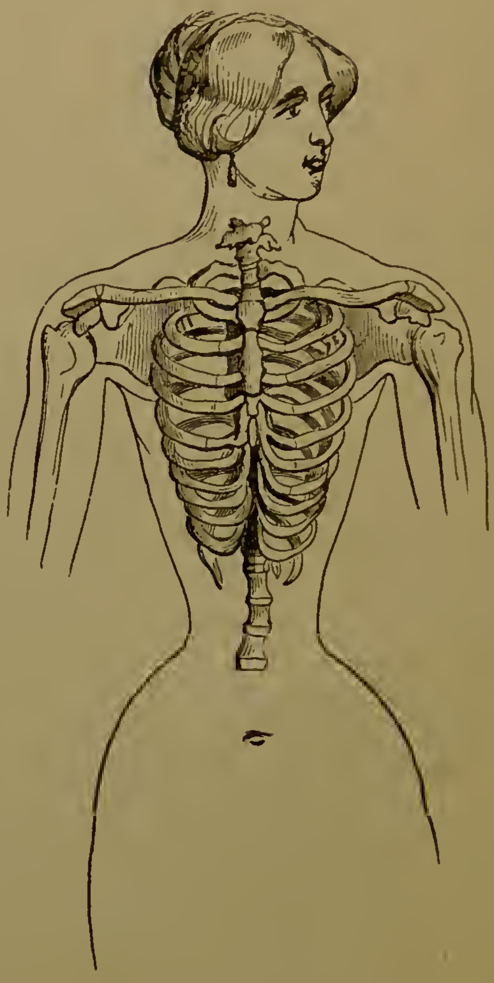

FIG. 25.—THE SAME IN A LADY DEFORMED BY STAYS.

ous organization. If girls will persist in ruining their vital orgns as they grow up to womanhood, and if women will con-

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How are longevity and happiness affected by fashionable dress? How are offspring affected by tight-lacing mothers?

tinue this destructive habit, the race must inevitably deteriorate. It may be asserted, therefore, without exaggeration that, not only the welfare of the future generations, but the salvation of the race depends on the correction of this evil habit.

The pathological consequences of continued and prolonged pressure on any vital structure are innutrition, congestion, inflammation and ulceration, resulting in weakness, waste of substance and destruction of tissue. The normal sensibility of the part is also destroyed. No woman can ever forget the pain she endured when she first applied the corsets; but in time the compressed organs become torpid; the muscles lose their contractile power, and she feels dependent on the mechanical support of the corset. But the mischief is not limited to local weakness and insensibility. The general strength and general sensibility correspond with the breathing capacity. If she has diminished her "breath of life," she has just to that extent destroyed all normal sensibility. She can neither feel nor think normally. But in place of pleasurable sensations and ennobling thoughts, are an indescribable array of aches, pains, weaknesses, irritations and nameless distresses of body, with dreamy vagaries, fitful impulses and morbid sentimentalities of mind.

And yet another evil is to be mentioned to render the catalogue complete. Every particle of food must be aerated in the lungs before it can be assimilated. It follows, therefore, that no one can be well-nourished who has not a full, free and unimpeded action of the lungs.

The effects of improper dress on the bony skeleton, and especially on the spinal column, are shown in Figs. 24, 25, 26 and 27, which every physician knows are not overdrawn.

In the contracted chest, represented by Fig. 25 (by no means an uncommon case), the external measurement is reduced one-half; but as the upper portions of the lungs cannot be fully inflated until the lower portions are fully expanded, it follows that the breathing capacity is diminished more than one-half. It is wonderful how any one can endure existence, or long survive, in this devitalized condition; yet thousands do, and,

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What are the pathological consequences of tight-lacing? How does it affect sensibility? How affect digestion?

with careful nursing, manage to bring into the world several sickly children.

The spinal distortion (Fig. 27) is one of the ordinary consequences of lacing. No one who laces habitually can have a

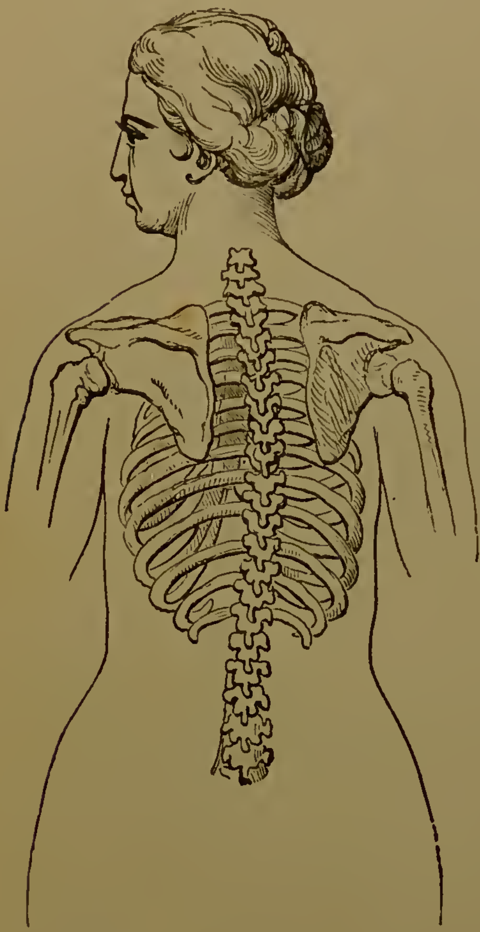

FIG. 26.—POSTERIOR VIEW OF THORAX IN A NATURAL STATE

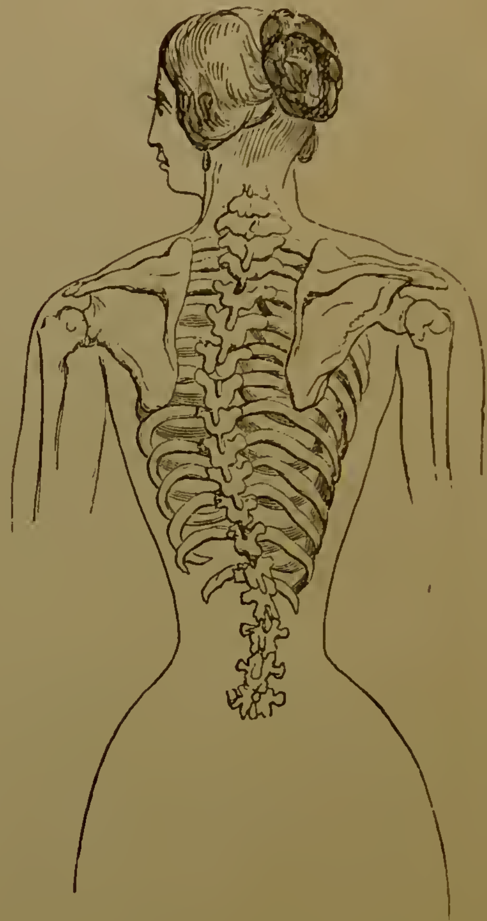

FIG. 27.—POSTERIOR VIEW OF THORAX COMPRESSED AND DEFORMED BY STAYS.

straight or strong back. The muscles being unbalanced, become flabby or contracted, unable to support the trunk of the body erect, and a curvature—usually a double curvature—of the spine is the consequence.

How does improper dress affect the spinal column? How the muscles? What malposition results?

And if anything were needed to aggravate the spinal curvature, intensify the compression of the internal viscera, and add to the general deformity, it is found in the modern contrivance of stilted gaiters. These are made with heels so high and narrow that locomotion is awkward and painful, the centre of gravity is shifted "to parts unknown," and the head is thrown forwards and the hips projected backwards to maintain perpendicularity, rendering walking and all other voluntary exercises not only distressing to the person, but disagreeable to the spectator.

To sit or stand in a crooked position, inclining the head and knees forwards, overstretches the middle spinal muscles, reverses the normal curvature of the spinal column, compresses the liver, stomach and lungs, and is in effect equivalent to lacing the waist. Figs. 28 and 29 show the right and wrong positions in standing.

Sleeping on two or three pillows, or on a bolster and pillow, is a prevalent yet pernicious custom. If long continued the effect is surely a distortion of the spine to some extent. If the head is raised high while sleeping, the stomach and lungs are injuriously compressed, and the upper intestines pressed downward on the pelvic organs. If children are allowed to sleep habitually on high pillows, spinal curvature and general debility will be the inevitable consequences. One pillow is enough for any person, and that should be only of moderate size. Figs. 30 and 31 exhibit the right and wrong positions in contrast.

Malpositions in sitting seem to be among the increasing evils of "high civilization" without physiological education. This habit is mainly attributable to the immensely unanatomical construction of chairs, benches, sofas, pews, etc. Not one school-house in all the land, not excepting those in which physiology is professedly taught, has a chair or a bench that a child can sit upright on without a constant and consciously painful effort. Nor have we ever seen, in private families or public institutions, halls or churches, stages or ferry-boats, railroad cars or steamers, a single seat constructed on hygienic

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What is the effect of high-heeled shoes? Of sitting or standing in crooked positions? Of high pillows? Of unanatomical seats?

principles. Figs. 32 and 33 show the normal and abnormal positions.

FIG. 28.—STANDING ERECT.

FIG. 29.—MALPOSITION.

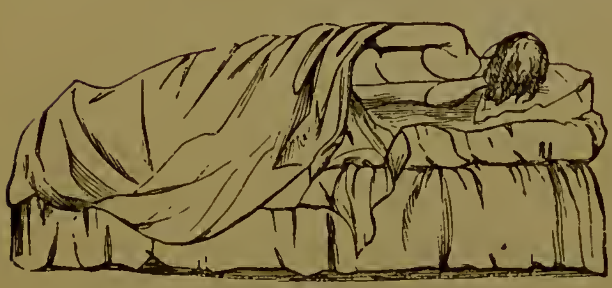

FIG. 30.—PROPER POSITION IN BED.

Children who early acquire and continue in the habit of sitting in normal or abnormal positions will either preserve the erectitude of the spinal column,

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How do the normal and abnormal positions acquired in childhood affect the person in adult life?

as shown in Fig. 34, or become crooked-backed, as seen in Fig. 35.

It is apparent that, inclining the head forwards and bending the body at the middle of the back, instead of on the hip-joints, necessitates a backward projection of the entire spinal column, with a corresponding incurvation or pressure anteriorly; hence the whole body is distorted from the crown of the head to the soles of the feet; more than a hundred muscles are unbalanced, and every organ and limb is weakened.

FIG. 31.—IMPROPER POSITION IN BED.

FIG. 32.—CORRECT SITTING POSITION.

FIG. 33.—MISPOSITION IN SITTING.

In all exercises, in walking, running, lifting and in manual labor, the power of the individual is always determined by the number of muscles that are brought into co-operative action.

How does bending the head and body affect the spinal column? How is muscular power to be measured?

But, if the body be crooked, or any part of it out of the normal relation to other parts, some muscles will be strained by over-action, while others will become relaxed from insufficient action, and all weakened—just as in the crooked ways of

34.—NATURAL SPINE.

35.—DISTORTED SPINE.

society some persons are drudged to death while others die of indolence.

If seats were properly constructed persons would sit upright, for the reason that it would be the most comfortable position. It would be painful to sit otherwise. The chairs, benches, sofas, pews or other seats, should fit the small of the back, the curve of the hips and the whole length of the thighs, as accurately as a well-made shoe is shaped to the foot, or harness to the body of a horse. But the commercial articles reverse this

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How are the muscles affected by malpositions? What is the principle for constructing anatomical seats?

rule; they press unduly on the upper part of the thighs and the upper part of the back, and afford no support whatever where it is principally needed. Moreover, in addition to the defective shape, they are, on the average, two inches too high, rendering it impossible for the feet to rest evenly and easily on the floor. No wonder that, on chairs which are a torment to one who tries to sit erect, persons are continually leaning back against the wall, drawing up their feet, placing one foot across the opposite knee, bracing one or both feet against the chair rounds or any adjacent object, and getting into all sorts of uncouth and ridiculous attitudes.

Fig. 36.—The Anatomical Seat.

The cut (Fig. 36) represents the out-line of our ideal chair. We place it on record for the benefit of the future generations, in the hope that some ingenious mechanic or pecunious philanthropist will supply one of the great wants of the age by introducing it.

In order to ascertain for himself the shape of a seat constructed on hygienic principles, the reader has only to seat himself erect in a common chair (after having sawed off the legs an inch or two, so that his feet will rest evenly on the floor), and have an assistant pad all the places where there are vacancies, until the chair or padding fits him from the shoulders to the knees. If this is accurately managed he will have the outline of a chair represented in the cut.

What are the objections to ordinary seats? What is the principle for the construction of hygienic seats?

CHAPTER V.

THE BODILY FRAMEWORK.

THE framework of the body is composed of the bones (Osteology) and ligaments (Syndesmology). The uses of the bones are to serve as fixed points for the attachment of muscles, whose contractions perform the principal motions of the body, and to form solid walls for the protection of the viscera. The ligaments bind the bones together.

In man the original framework of the body is cartilaginous. The greater portion of this cartilage becomes ossified in time, and is hence termed *temporary;* but in some places it remains *permanent*, and so covers the adjacent surfaces of bones as to admit, in consequence of its elasticity, of some degree of motion between them, as in the case of the vertebræ of the spinal column. Cartilage also forms a considerable part of the framework of the chest, connecting the lower or short ribs with the breast-bone, or *sternum.* Another kind of cartilage is arranged in the form of plates, or *lamellæ*, and forms the shape of canals and passages, as in the external ear, nose, eustachian tube, larynx, and windpipe.

In the movable joints the ligaments are lined with a membrane (*Synovial*), which secretes a lubricating fluid (*Synovia*).

The relation which the bony structure bears to the whole body is represented in Fig. 37.

COMPOSITION OF BONE.

The proximate constituents of bone, as determined by chemical analysis, are:

Cartilage	(parts)	32.17
Blood-vessels,	"	1.13
Phosphate of lime	"	51.04

Of what is the bodily framework composed? What is temporary cartilage. Permanent? What is Synovia?

Carbonate of lime,	(parts)	11.30
Fluate of lime,	"	2.00
Phosphate of Magnesia,	"	1.16
Soda, Chloride of Sodium,	"	1.20
		100.00

But, as chemistry is always destructive, and never constructive, it must be remembered that chemical analyses, so far from determining the constituents of an organic structure, only ascertain what elements are left after the analysis is completed. The peculiarity of living matter, as we shall explain hereafter, consists more in molecular arrangement than in elementary constituents, and of this chemistry can never take cognizance.

THE SKELETON.

The skeleton of an adult human being consists of two hundred and forty-six distinct pieces.

Bones of the head,	8
Ear—ossicula auditus,	6
Face,	14
Teeth,	32
Back,—vertebral column	24
Ribs,—twelve pairs.	24
Tongue,—os hyoides	1
Upper extremities	64
Breast,—sternum,	1
Pelvis,	4
Lower extremities,	60
Sesamoid,—average,	8
	246

Some anatomists exclude the sesamoid bones and teeth in their enumeration of the pieces of the skeleton, because their structure, development and growth are different from ordinary bone.

Although the human skeleton is far from being a "thing of beauty" to the careless observer, it is to the philosophic mind an admirable study. No one would think of it to embel

What is the composition of bone? How many bones compose the human skeleton?

lish a book, ornament a parlor, or grace an exhibition of the fine arts. Yet no part of a living structure, not even the brain itself, better illustrates the idea of supreme wisdom, and declares that,

"The hand that made us is Divine."

Every rough surface, every projection or depression, every notch, canal and foramina, has some special use and adaptation. It serves for the attachment of muscles, the passage of vessels and nerves, and the protection of vital parts. Nothing is amiss. No human ingenuity could improve the workmanship by adding or abstracting.

FIG. 37—RELATIONS OF BONES TO BULK.

The dome of the capitol at Washington is said to be the most magnificent structure of the kind on the earth. And when the irregular parts, angular castings, and rough materials of its framework were being prepared and adjusted, no one but an accomplished architect could imagine what they were intended for. But the builders displayed quite as much skill in contriving them as they did in planning the beautiful curves and graceful proportions of its exterior.

STRUCTURE OF BONE.

The bony structure cannot be said to possess any distinctive vital property; but

What purposes do the projections, depressions, etc., of bone subserve? Has bony structure any distinct vital property?

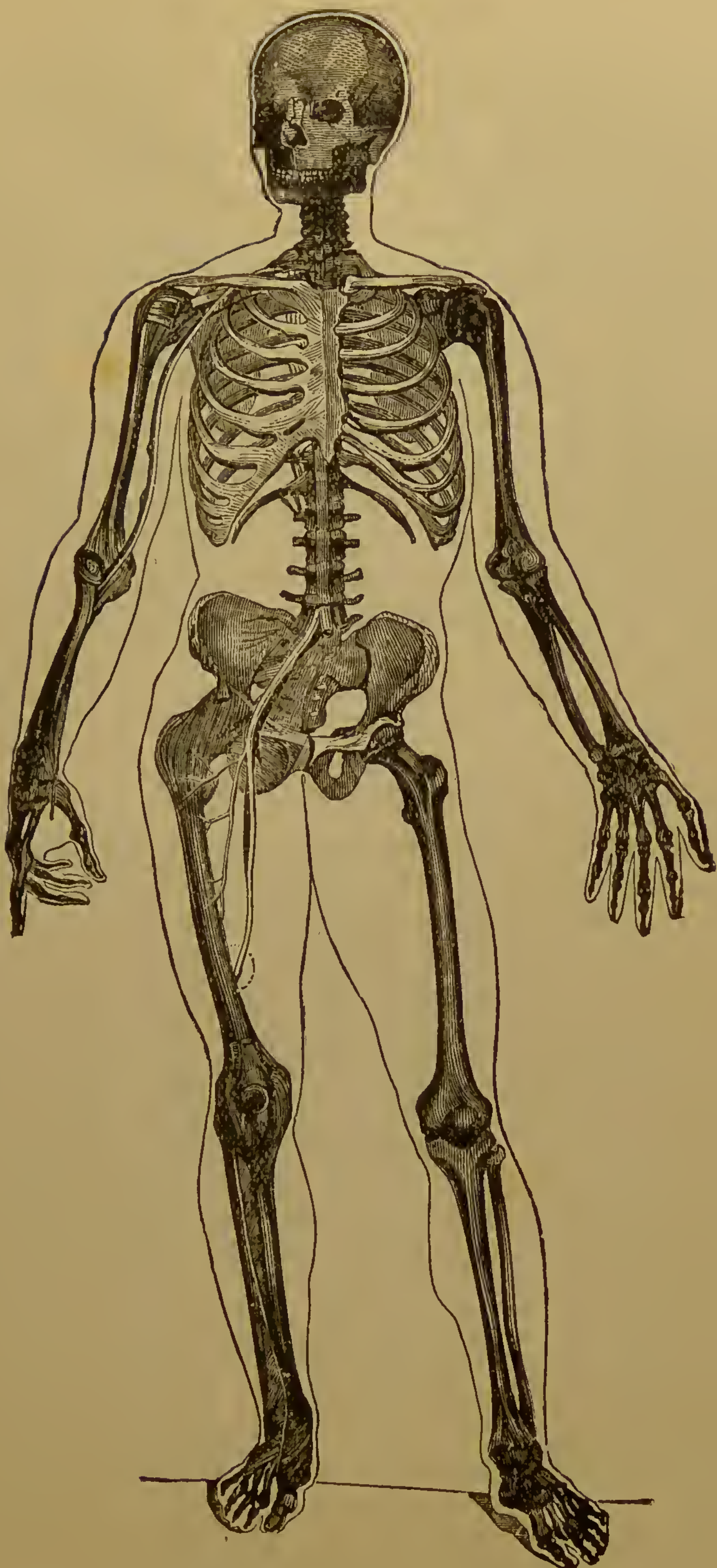

Fig. 38.—The Osseous System.

as it is traversed by blood-vessels and nerves, its vitality pertains to its muscular and nervous tissues. Bone is a dense subfibrous basis filled with minute cells, and traversed in all directions by inosculating canals, termed *Haversian*, which give passage to vessels and nerves. These cells are irregular in form, and give off numerous branching tubes, which, by various intercommunications, constitute a very delicate network.

INVESTING MEMBRANE.

All bones are covered with a dense fibrous membrane, termed *periosteum*, except at their articulating surfaces, where they are lined with a thin layer of cartilage. That portion of the periosteum which covers the bones of the skull is termed, *pericranium*, and where it is extended over cartilages, it is called *perichrondrium.* The internal cavities of long bones, and the canals and cells of others, are lined by a membrane termed *medullary*, and filled with an oily substance, termed *medulla*, or marrow.

DEVELOPMENT OF BONE.

Like **all** organized structures, the osseous exists primordially in the condition of extremely minute vesicles, or cells. Each cell is composed of a thin membrane, enclosing a fluid matter, in which is a small, denser mass, constituting the *nucleus* around which the cell itself was originally developed. Within each nucleus may usually be found one or more smaller granules, or cells, termed *nucleolus*, or *nucleoli.* In the language of the *Hydropathic Encyclopædia*, "And whether there are within these nucleoli yet smaller vesicles, and within them more minute nucleoli still, and so on, must be left to imagination. The human mind must grasp infinity before it can comprehend the primal atom, or starting point, of vital organization."

STAGES OF OSSIFICATION.

Although the bony structure may be regarded as the primary and lowest grade of organized matter (unless we except the woody fibers of the vegetable), yet its development and growth

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What are Haversian canals? What is periosteum? Pericranium? Perichrondrium? Of what is a cell composed?

are still among the marvels of living things. Why and how its elements arrange themselves, or are arranged, into one tissue instead of another, and into definite relations to each other, science has not yet revealed. All that philosophy or faith can say, in the present state of our knowledge, is, "*There is a power which directs all.*"

Fig. 39 represents a microscopic view of the structure of bone. 1. One of the Haversian canals. 2. The same, with the cells and tubuli. 3. Area of one of the canals. 4 4. Direction of the medullary or central part. The upper part of the cut represents several long cells with their tubuli; the lower part shows the outlines of several other canals.

FIG. 39.—MINUTE STRUCTURE OF BONE.

Histologists distinguish three stages in the process by which bone is formed, *gelatinous*, *cartilaginous*, and *ossific*. The first recognizable change of ordinary vesicles towards bony structure is an aggregation of minute cells, of a jelly-like consistence. In the process of growth these cells are separated by intercellular substance, which is transparent and fluid at first, but gradually becomes condensed and opake, constituting the cartilaginous stage of ossification. Vascular canals are next formed, by a union of cells in rows and the liquefaction of the adhering surfaces. The next distinct change is into osseous substance. This is effected by the concentration of all the vascular canals to central points, each one of which is termed, *punctum ossificationis.* "As the earthy particles are deposited around the central point," says the work above quoted, "the surrounding cartilaginous cells become elongated, and within each cell two or three nucleoli are developed. Each of these secondary cells

What are the stages of ossification? What is understood by punctum ossificationis?

soon attains the size of the parent cell, the membrance of which disappears, and the newly-formed cells are separated by freshly-effused intercellular substance. Still progressing, each newly-formed cell produces four, five, or six young cells, which destroy the parent membrane, and attain a larger size, that of the parent cell being 1–1500th of an inch in diameter, all the cells being separated as before by intercellular substance. This process of reproduction is repeated yet again, each cell producing as many as its parent did, which form in clusters of from thirty to fifty. The clusters are oval in figure, and are disposed longitudinally to the axis of the bone, while the cells are arranged transversely. Very fine and delicate fibers, within the intercellular substance, commencing at the ossifying point, and extending through every part of the bone, longitudinally in long, and radiatingly in flat bones, are, lastly, formed, and complete the process of ossification. These fibres embrace each cluster of cells, and send branches between the individual cells of each group, by which the network of bone is formed, while the areolæ and Haversian canals are formed by the conjunction of the cells. A highly magnifying power shows the ossific fibers to be composed of minute cells, of an elliptical form, and having central nucleoli."

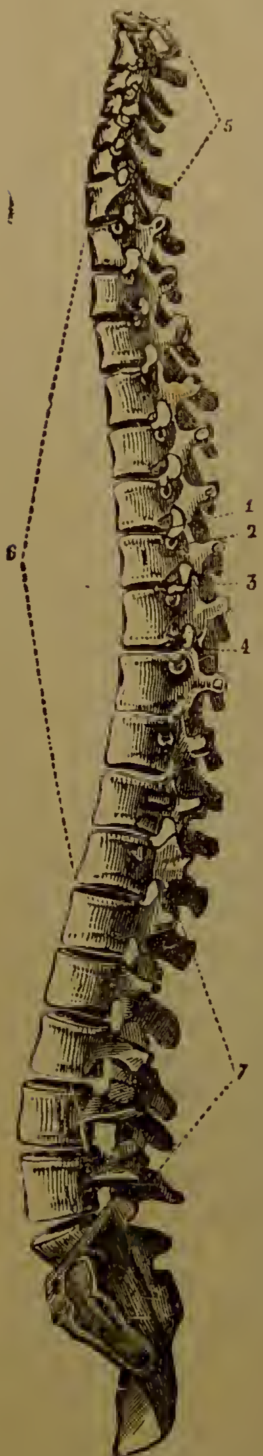

Fig. 40—Vertebral Column.

The divisions of true vertebræ and the distinct parts of each are shown in Fig. 40, which represents the vertebral column entire as seen from the left side. 1. Two semi-facets, which articulate with the head of the rib. 2. Spinous process. 3, 4. Two foramina, each resulting from the union of two vertebræ. 5. Cervical region and its corresponding curve. 6. Dorsal region and its corresponding curve. 7. Lumbar region and its corresponding curve. 8. Sacrum.

How are Haversian canals formed? Of what are ossific fibres composed? What are the regions of the vertebral column?

THE VERTEBRAL COLUMN.

The bones of the back, constituting the vertebral column, are divided into the seven *cervical*, belonging to the neck, the twelve *dorsal*, forming the central portion of the column, and the five *lumbar*, pertaining to the loins. These twenty-four pieces constitute the *true vertebræ* in contradistinction to the *false vertebræ*, which are the pelvic continuation of the spinal column. The false vertebræ are divided into the *sacrum* and *coccyx*. In young persons the sacrum consists of five pieces, and the coccyx of four, so that the vertebral column originally comprises thirty three pieces.

The distinctive parts of a vertebra are shown in Fig. 41. 1. The body, concave in the centre, and rising into a sharp ridge on each side. 2. The lamina. 3. The part termed pedicle, rendered concave by the superior intervertebral notch. 4. Spinous process, its extremity bifurcated. 5. Transverse process. 6. Vertebral foramen. 7. Superior articular process. 8. Inferior articular process.

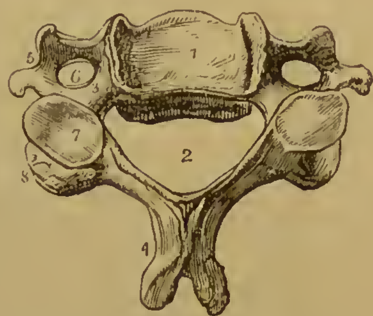

Fig. 41.—A Cervical Vertebra.

The first cervical vertebra, termed *atlas*, is exceptional in having no body, while the second cervical, *dentatus*, has a tooth-like projection around which the atlas moves, constituting the neck-joint.

In the plate (Figs. 42 to 49) are represented all the bones of the trunk, with the shoulder blades, bones of the pelvis, and the different kinds of vertebræ.

The first cervical vertebra supports the head, hence its name, *atlas*. It is a simple ring of bone moving on the second cervical, which is called the *axis*.

The *axis* has a large body, and its strong, tooth-like process, called *odontoid*, rises perpendicularly, and is articulated with the anterior arch of the atlas, while its posterior surface is firmly bound by a strong transverse ligament. The atlas, turning on the axis, moves the head laterally as though it were turning on a pivot, as well as to some extent forward and backward.

The *seventh cervical vertebra* is termed *prominens*, because its

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How is the vertebral column divided? Of how many pieces is it composed? What are the distinctive parts of each?

FIG. 44.

FIG. 45.

FIG. 43.

FIG. 46.

FIG. 42.

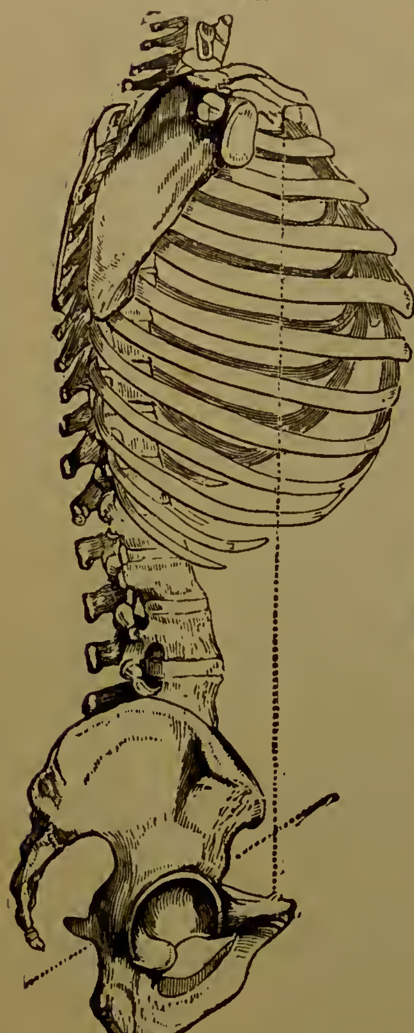


FIG. 47.

FIG. 48.

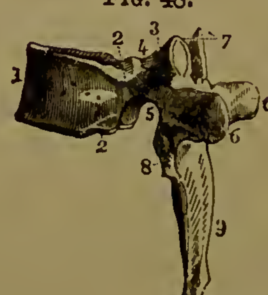
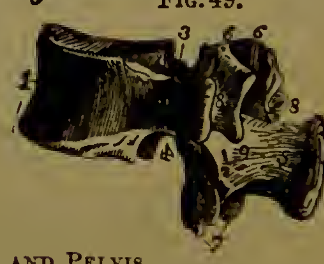


FIG. 49.



BONES OF THE BACK, TRUNK, AND PELVIS.

Fig. 42. Framework of trunk. Fig. 43. Spinal column; 1, atlas (Fig. 45, upper, Fig. 44, lower view of same); 2, dentatus (Fig. 46, upper view); 2 to 3, other cervical vertebræ (Fig. 47, upper view of); 4 to 6, dorsal vertebræ (Fig. 48, side view of one); 5 to 7, lumbar vertebræ (Fig. 49, side view of one); 8 to 9, sacrum; below 9, coccyx.

spinous process projects backwards beyond the others, thus occasioning the prominent part of the back of the neck—a fact to be kept in mind by persons who desire not to mistake a normal condition for a deformity or miscurvature. This prominence is terminated by a tubercle, to which the strong ligament of the neck, *ligamentum nuchæ*, is attached.

The *dorsal* vertebræ are articulated with the ribs, for which purpose each one is marked on each side with *facets* for receiving the heads of the ribs.

The *lumbar vertebræ* are the largest; their bodies are thicker before than behind; their spinal cavity is large and oval, and their spinous processes are thick and broad.

The *sacrum* is of a triangular figure, concave in front and convex behind. It is marked, in the adult, by four transverse ridges, which indicate the consolidation of the five separate pieces.

The *coccyx*, which terminates the vertebral column inferiorly, is composed originally of four small pieces (shown in Fig. 43), which gradually unite into one; and this one becomes consolidated with the sacrum soon after the middle period of life.

"The *whole vertebral column*," says the "Hydropathic Encyclopædia," "represents two pyramids, with 'bases applied to each other,' the sacrum and coccyx constituting the lower, and all the vertebræ, except the atlas, forming the upper. The *bodies* of the vertebræ are broad in the cervical region, narrower in the middle of the dorsal, and again broad in the lumbar region. The *spinous processes* are horizontal in the cervical, gradually becoming oblique in the upper part of the dorsal, nearly vertical and imbricated in the middle of the back, and again horizontal towards the lower part. The *transverse processes* gradually increase in length from the axis to the first dorsal vertebra; in the dorsal region they project obliquely backward, and diminish suddenly in length in the eleventh or twelfth, where they are very small. The *intervertebral foramina* are openings formed by the juxtaposition of the vertebral notches; they are smallest in the cervical region, gradually enlarging to the lumbar. The *vertebral groove* extends the whole length of the column

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What forms the prominent part of the back of the neck? What is the shape of the whole vertebral column?

on either side of the spinous processes, for lodging the principal muscles of the back."

BONES OF THE CHEST.

The twelve pairs of ribs on the sides, and the sternum, or breast-bone, in front, constitute the thōrax.

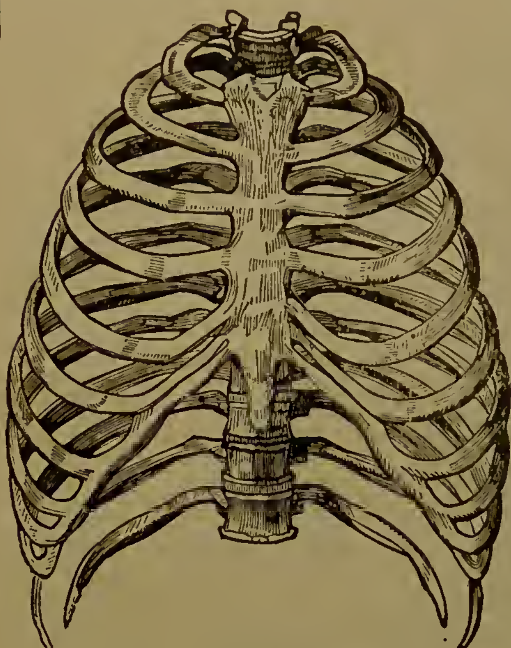

Fig. 50.—The Thorax.

Fig. 50 is a front view of the thorax. 1. The *manubrium* (upper portion of the sternum). 2. Its body (middle portion). 3. Its ensiform cartilage (lower portion). 4. First dorsal vertebra. 5. Last dorsal vertebra. 6. First rib. 7. Head of first rib. 8. Its neck. 9. Its tubercle. 10. Seventh rib. 11. Costal cartilages of the ribs. 12. Last two false ribs. 13. The groove along the lower border of each rib.

The upper seven pairs of ribs are termed *sternal*, or *true ribs*, because they are articulated with the sternum. The five lower pairs are termed *false*, or *asternal*, because they are connected with each other in front by cartilages, instead of being joined to the sternum.

The ribs increase in length from the first to the eighth, and then diminish to the twelfth. In breadth they diminish from the first to the tenth. The first is horizontal, the rest oblique, the sternal end falling considerably below the vertebral end. The vertebral end of the rib is expanded into a *head* for articulation with two contiguous vertebræ. The two lower ribs are termed *floating*, and are much shorter than the others. The sternal ends of the ribs are cartilaginous, thus contributing mainly to the elasticity of the thorax; in old age these *costal cartilages* are more or less ossified. The upper seven cartilages articulate with the sternum; the eighth, ninth and tenth artic-

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What bones constitute the thorax? What are sternal ribs? True? False? How many ribs are there?

ulate with the lower border of the ones above; the eleventh and twelfth lie free between the abdominal muscles. Each rib articulates with two vertebræ posteriorly, and with one costal cartilage anteriorly, with the exception of the first, tenth, eleventh and twelfth, which are each articulated with a single vertebra.

BONES OF THE PELVIS.

The pelvis is composed of the two bones (*ossa innominata*) which form its sides and front, and the sacrum and coccyx behind. Anatomists distinguish the pelvis into the *true* and the *false*. The *true pelvis* is the portion beneath the *linea ilio pectinea* (*k*, *k*, Fig. 51), which forms the margin or brim of the proper pelvic cavity. The *false pelvis* is the part immediately above, and is really the lower part of the cavity of the abdomen.

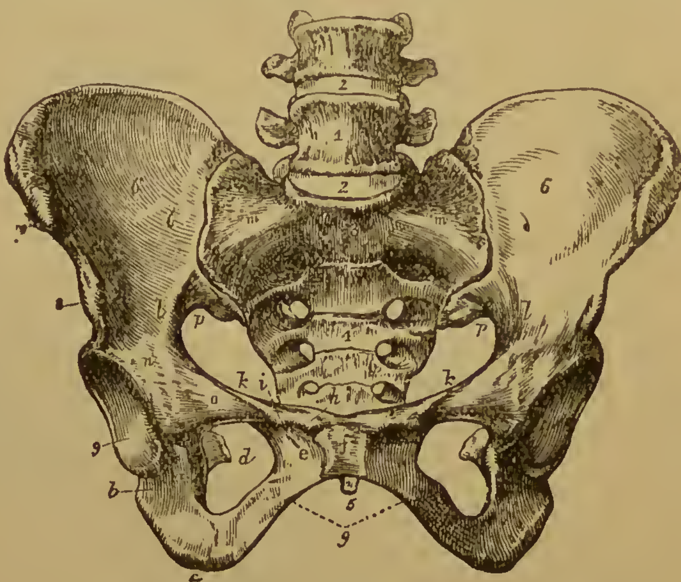

Fig. 51.—The Pelvis.

Fig. 51 is a front view of the pelvis. 1. The last lumbar vertebra. 2 2. The intervertebral substance connecting the last lumbar vertebra with the one above, and with the sacrum below. 3. Promontory of the sacrum. 4. Anterior surface of the sacrum, on which the transverse lines and foramina are seen. 5. Lower point of the coccyx. 6, 6. The iliac fossæ, forming the lateral boundaries of the false pelvis. 7. Anterior superior spinous process of the ilium—left side. 8. Anterior inferior spinous process. 9. The acetabulum. *q*. The notch of the acetabulum. *b*. Body of the ischium. *c*. Its tuberosity. *d*. The spine of the ischium seen through the obturator foramen. *e*. Os pubis, *f*. Symphisis pubis. *g*. Arch of the pubis. *h*. Angle of the os pubis. *i*. Spine of the pubis; the prominent ridge between *h* and *i* is the crest of the pubis. *k*, *k*. Pectineal line of the pubis. *l*, *l*. The ilio-pectineal line; *m*. *m*, its prolongation to the promontory of the sacrum. The brim of the true pelvis is represented by the line *h*, *i*, *k*, *k*, *l*, *l*, *m*, *m*. *n*. The ilio-pectineal eminence. *o*. The smooth surface which supports the femoral vessels *p*, *p*. The great ischiatic notch.

What bones constitute the pelvis? What is the true pelvis? False? What is the brim of the pelvis?

In relation to the trunk of the body the pelvis is situated obliquely, the inner surface of the pubic bones being directed upward to support the superincumbent weight of the abdominal viscera. Its cavity measures, in depth, four and a half inches posteriorly, and one and a half inch at the symphisis pubis.

Each *os innominatum* is distinguished anatomically into three distinct portions, termed os ilium, os ischium, and os pubis. In the young person these portions constitute separate bones.

The *ilium* is the upper expanded portion of the pelvis forming the prominence of the hip, and articulating with the sacrum. The *ischium* is the lower strong part on which the body rests in sitting. The *pubis* forms the front part of the pelvis.

The *acetabulum* is a deep cavity, at the junction of the ilium, ischium and pubis, for receiving the head of the thigh bone. Between the ischium and the pubis is a large oval opening, termed *obturator foramen;* it is covered with a ligamentous membrane. A groove in the upper part lodges the obturator vessels and nerves.

BONES OF THE HEAD.

THE bones of the head, constituting the *skull*, are divided into those of the *cranium* and those of the *face*. The cranial bones are eight and the facial fourteen in number:

CRANIAL BONES.

Occipital,	Two Temporal,	Two Parietal,
Sphenoid,	Frontal,	Ethmoid.

FACIAL BONES.

Two Nasal,	Two Palate,	Two Superior Maxillary,
Two Inferior Turbinated,	Two Lachrymal,	Two Malar,
Inferior Maxillary.	Vomer,	

Like all flat bones, those of the cranium are composed of two plates or tables, and an intervening cellular net-work, termed *diploe*, which contains an oily, medullary substance. This struc-

---

How many bones of the head? Cranial? Facial? Of what are flat bones composed?

ture is much better calculated to protect the brain against the effects of falls, blows, and shocks of all kinds than a more solid structure would be.

The *Occipital bone* forms the base and back part of the cranium. Its external surface is marked by two transverse ridges. In its lower portion is a large opening, termed *foramen magnum*, through which the spinal cord is connected with the brain. On each side of the foramen magnum are processes termed *condyles*, for articulating the os occipitis with the atlas. Its internal surface is divided by a crucial ridge into four depressions, termed *fossæ*. In the upper depressions are situated the posterior lobes of the cerebrum, and in the lower ones the lateral lobes of the cerebellum. In front of the foramen magnum is a

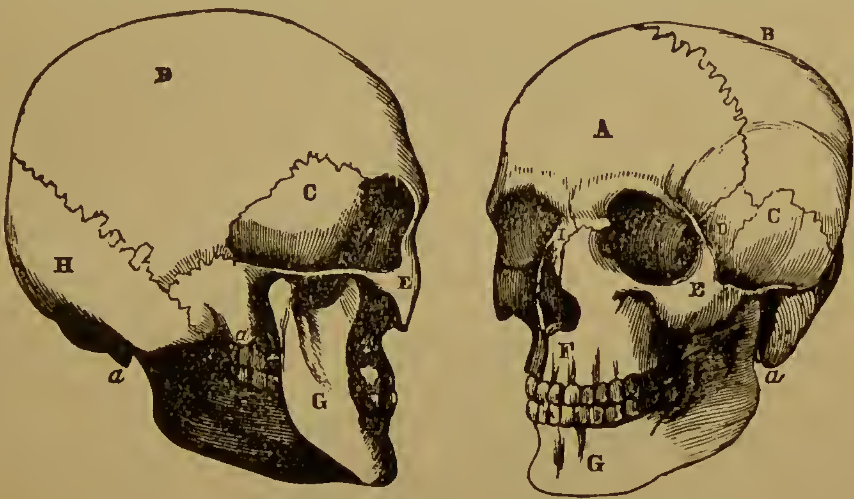

FIG. 52.—BONES OF THE HEAD.

Fig. 52 represents a front and side view of the bones of the head. A. Frontal bone. B B. Parietal. C C. Temporal. D D. Sphenoid. E E. Malar. F F. Superior maxillary. G G. Inferior maxillary. H. Occipital. I. Nasal. *a a*. Mastoid process of the temporal bone.

projection termed the *basilar process*, on which rests the medulla oblongata.

The *Parietal bones* are situated at the side and vertex of the skull, and are connected with each other by a straight suture, termed *sagittal*. Each is quadrilateral in form, and on the external surface of each is an arched line, termed the *temporal*

What part of the skull does the occipital bone form? What vertebra is it articulated with? Where are the parietal bones situated?

ridge. The internal surface is marked by numerous furrows and depressions, the former lodging arteries, and the latter corresponding with the convolutions of the brain.

The *Frontal bone* forms the forehead and part of the roof of the nostrils and orbits of the eyes. Each lateral half of the bone projects forward, forming the *frontal eminences.* Below these points are the *superciliary ridges*, which support the eye-brows. On the orbital portions of the internal surface are *fossæ*, corresponding to the convolutions of the anterior lobes of the cerebrum.

The *Temporal bones* are situated at the side and base of the skull, and are divided into squamous, mastoid, and petrous portions. The *squamous* portion is the thin semi-translucent part of the temple, and its inner surface is irregularly depressed by the convolutions of the cerebrum. A long arched process extends from its external surface, termed the *zygoma.* The *mastoid* portion forms the back part of the bone. In front of it is the *meatus auditorius externus*, or external ear passage, and its interior is arranged into numerous cells, which belong to the organ of hearing. The *petrous* portion is hard and dense; and near the middle of its posterior surface is the *meatus auditorius internus.* The *basilar* surface forms a part of the under surface of the base of the skull. The condyle of the lower jaw is articulated to a smooth fossa in this bone, termed *glenoid.* At the inner angle of this fossa is the foramen of the Eustachian tube, which connects the cavity of the internal ear with the throat. Deafness is frequently owing to the obstruction of this tube.

The *Sphenoid bone* is situated at the base of the skull, and assists in the formation of the cranium and face. It is named from its resemblance to a bat with its wings extended.

The *Ethmoid bone* (sieve-like) is a small, square, thin bone between the orbits at the root of the nose. It is perforated with numerous openings. A thin curled plate of its internal surface is called the *superior turbinated bone*, and below another thin plate outward, forming the *middle turbinated bone.* Between these is a narrow fissure, the upper meatus of the nose. The

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What does the frontal bone form? Temporal bones? Where is the sphenoid situated? Ethmoid?

turbinated or *spongy* bones are the usual seat of polypous tumors.

The *Nasal bones* (of the nose) are small quadrangular pieces, forming the bridge of the nose.

The *Superior Maxillary bones* form the upper jaw, and assist in the formation of the orbit, nose, cheek, and palate. The interior of each is hollow, forming the *antrum*. Its lower portion presents the *alveolar processes* for containing the upper teeth.

The *Lachrymal bones* are thin oval plates at the anterior and inner angles of the orbits of the eyes.

The *Malar bones* are quadrangular pieces forming the prominence of the cheek.

The *Palate bones* enter into the formation of the palate, side of the nose, and back part of the floor of the orbit.

The *Inferior Turbinated bones* are light, spongy, curved bones projecting inward toward the *septum narium*, or partition of the nose.

The *Vomer* is a thin quadrilateral piece, forming the back and lower part of the septum of the nose.

The *Inferior Maxillary bone* is the lower jaw. It is an arch of bone containing the under teeth.

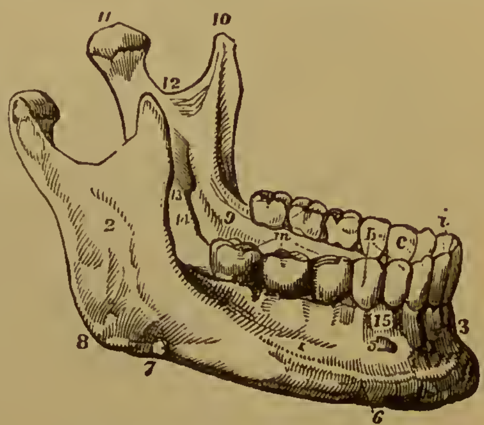

Fig. 53.—Lower Jaw.

The different parts of the lower jaw are represented in Fig. 53. 1. Body. 2. Ramus. 3. Symphisis. 4. Fossa for the depressing muscle of the lower jaw. 5. Mental foramen. 6. External oblique ridge. 7. Groove for the facial artery. 8. Angle. 9. Extremity of milo-hyoidean ridge. 10. Coronoid process. 11. Condyles which articulate with the glenoid cavity of the temporal bone. 12. Sigmoid notch. 13. Inferior dental foramen. 14. Milo-hyoidean groove. 15. Alveolar process.

SUTURES OF THE SKULL.

The principal *sutures* (seams) of the skull are the *coronal*,

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What do the nasal bones form? Superior maxillary? Lachrymal? Malar? Palate? Inferior turbinated? Vomer? Inferior maxillary?

which extends transversely across the crown, uniting the frontal

FIG. 54.—FRONT VIEW OF THE SKULL.

Fig. 54 exhibits several minute peculiarities of structure not described in the text. 1. The frontal portion of the frontal bone. 2. Nasal tuberosity. 3. Supra-orbital ridge. 4. Optic foramen. 5. A fissure, called sphenoidal. 6. Another fissure, called spheno-maxillary. 7. The lachrymal fossa. 8. Opening of the anterior nares, the vomer in the centre, on which the figure is placed. 9. Infra-orbital foramen. 10. Malar bone. 11. Symphisis, or point of union of the lower jaw. 12. Mental foramen. 13. Ramus of the lower jaw. 14. Parietal bone. 15. Coronal suture. 16 Temporal bone. 17. Squamous suture. 18. Upper part, or greater wings, of sphenoid bone. 19. Commencement of temporal ridge. 20. Zygoma of temporal bone, forming, with the malar, the zygomatic arch, under which is the zygomatic fossa. 21. The mastoid process.

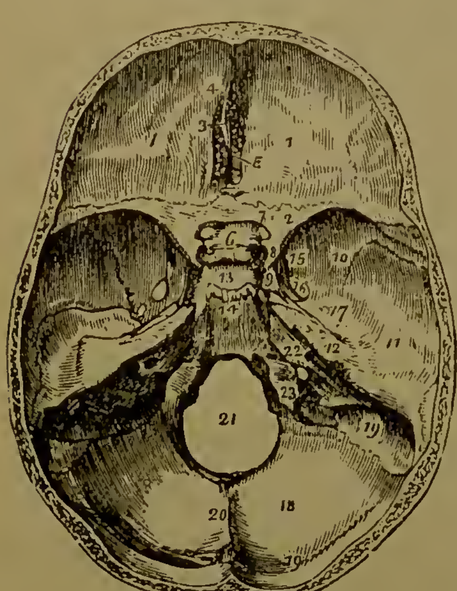

FIG. 55.—INNER BASE OF THE SKULL.

Fig. 55 represents the cerebral surface of the base of the skull. 1. One side of the anterior fossa. 2. Lesser wing of the sphenoid. 3. Crista galli. 4. Foramen cæcum. 5. Cribriform lamella of the ethmoid. 6. The process called *olivary*. 7. Foramen opticum. 8. Anterior clinoid process. 9. The carotid groove on the side of the sella turcica, for the internal carotid artery and cavernous sinus. 10, 11, 12. Middle fossa of the base of the skull; 10 marks the great ala of the sphenoid; 11, the squamous portion of the temporal bone; 12, the petrous portion. 13. The sella turcica. 14. Basilar portion of sphenoid and occipital bones. The uneven ridge between 13 and 14 is called *dorsum* ephippii, and the prominent angles of the ridge constitute the posterior clinoid processes. 15. Foramen rotundum. 16. Foramen ovale. 17. Foramen spinosum; a small opening between 17 and 12 is called *hiatus fallopii*. 18. Posterior fossa of the base of the skull. 19, 19. The groove for the lateral sinus. 20. The ridge upon the occipital bone, to which the *falx cerebelli* is attached. 21. Foramen magnum. 22. Meatus auditorius internus. .23. Jugular foramen.

What are the principal sutures of the skull? What is the meaning of suture?

and parietal bones; the *sagittal*, which unites the two parietal bones, and forms the longitudinal seam along the vertex; the *lambdoidal*, which connects the occipital and parietal bones, and the *squamous*, which unites the squamous portion of the temporal bone with the parietal and sphenoid.

ORBITS OF THE EYE.

These are hollow cones for the lodgment of the eyeballs and their muscles, vessels, nerves, and lachrymal glands. Communicating with the orbit are nine openings for the transmission of arteries, veins and nerves. The frontal, ethmoid, malar, superior maxillary, palate, and lachrymal bones contribute to the formation of the orbits.

THE NASAL CAVITIES.

Each nasal cavity is divided into three irregular longitudinal passages, termed *meatuses*, by three projecting processes of bone from the outer wall. These projections constitute the superior, middle, and inferior turbinated bones. The lower meatus is much the largest.

THE TEETH.

Human beings are provided with two sets of teeth, *deciduous* and *permanent*. The deciduous teeth (milk teeth) are those of childhood, and are twenty in number; eight *incisor*, or cutting, four *canine*, and eight *molars*, or grinding teeth.

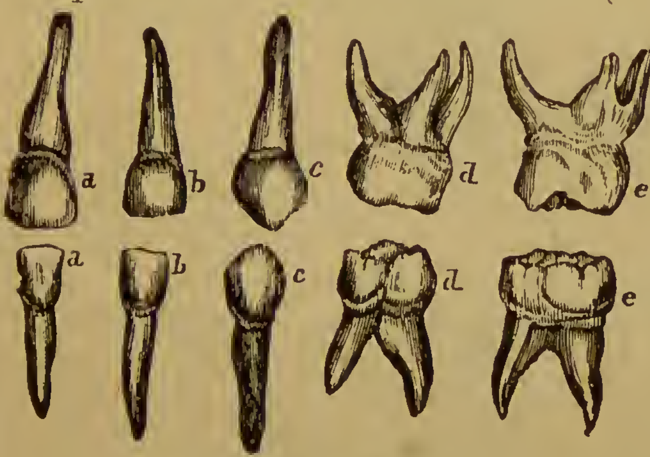

Fig. 56.—Temporary Teeth.

In Fig. 56 are shown the different kinds of temporary teeth. *a*. Central incisor. *b*. Lateral incisor. *c*. Canine. *d*. First molar. *e*. Second molar.

The permanent teeth are thirty-two, sixteen in each jaw.

What are orbits of the eye? How are the nasal cavities divided? How many deciduous teeth? Permanent?

Each lateral half of each jaw, reckoning from the centre, con-

Fig. 57.—Permanent Teeth.

In Fig. 57, *a* is the central incisor. *b*. Lateral incisor. *c*. Cuspid, or canine. *d*. First bicuspid. *e*. Second bicuspid. *f*. First molar. *g*. Second molar. *h*. Third molar.

tains two incisors, one canine, or eye-tooth, two bicuspids, or small double, and three molars, as represented in Fig. 57.

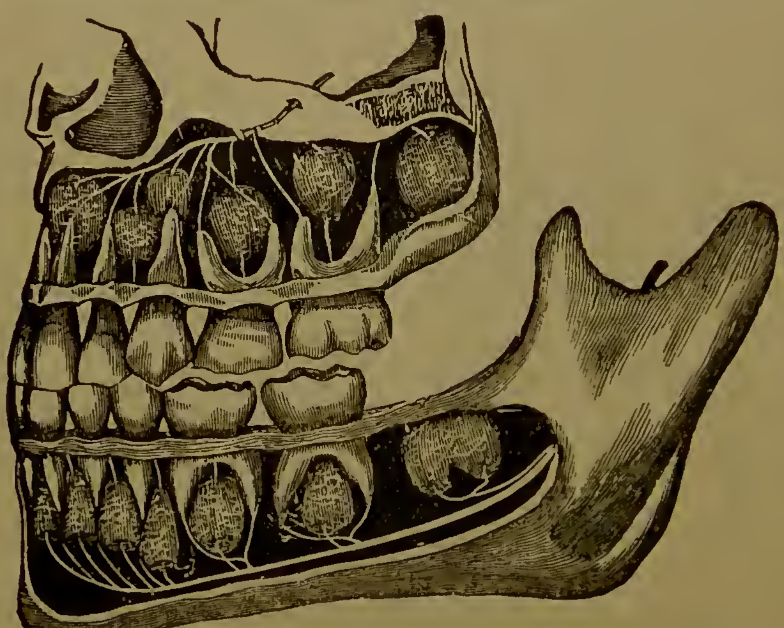

Fig. 58.—Infant Teeth and Rudiments of the Permanent.

How many kinds of teeth are there? What number of each?

Each tooth is composed of a firm external crust, termed *enamel;* the proper bone of the teeth, termed the *ivory*, and a cortical substance, termed *cementum*, which forms a thin coating over the rest of the tooth. Its structure is similar to that of bone, and exhibits cells and tubuli.

In Fig. 58 are seen the number, arrangement, and nervous connections of a complete set of deciduous teeth, with the rudiments of the permanent teeth, as they appear at four years of age.

PERIODS OF DENTITION.

The first set of teeth usually appear in the following order, the teeth of the lower jaw generally preceding those of the upper. In the *seventh* month the two middle incisors; in the *ninth* the two lateral incisors; in the *twelfth* the first molars; in the *eighteenth* the canine; and in the *twenty-fourth* the last two molars.

The order of the second set of teeth is:

First molars, at 6½ years.	Second bicuspids, 10th year.
Two middle incisors, 7th year.	Canine, 11th to 12th year.
Two lateral incisors, 8th year.	Second molars, 12th to 13th year.
First bicuspids, 9th year.	Last molars, 18th to 21st year.

The last molar or grinding tooth occasionally does not appear until twenty or thirty years of age, or even later, from which circumstance it is termed the wisdom tooth—*dens sapiente.*

BONE OF THE TONGUE.

The *hyoid* or tongue bone (*os hyoides*) is situated at the base of the tongue, supporting it and the upper part of the larynx.

FIG. 59.—OS HYOIDES.

Fig. 59 is a front view of the bone of the tongue. 1. Its convex, or antero-superior side. 2. Greater cornua of the left side. 3. Lesser cornua.

In early life the cornua and body are connected by ligaments and cartilages, which in old age become ossified.

In what order do the deciduous teeth appear? The permanent? What is the last molar called? Situation and use of the hyoid bone?

BONES OF THE UPPER EXTREMITIES.

EACH upper extremity comprises:

The Clavicle,—collar bone, . . .	1
The Scapula,—shoulder blade	1
The Humerus,—arm bone.	1
The Radius and Ulna,—Two arm bones . .	2
The Carpus,—wrist bones	8
The Metacarpus,—hand bones	5
The Phalanges,—finger bones	14

BONES OF THE SHOULDER.

The *Clavicle* extends across the upper side of the chest, connecting the upper end of the sternum with the shoulder, being articulated with the clavicle.

The *Scapula* is a flat triangular bone, occupying the space from the second to the seventh rib, upon the posterior aspect and side of the thorax. The thick anterior angle of the bone is called its *head;* and in this head is a shallow articulating surface called the *glenoid cavity*, which receives the head of the humerus. Above the glenoid cavity is a projection termed the *acromion*, on the outer border of which is an oval articular surface for the clavicle.

BONES OF THE ARM.

The *Humerus* consists of a long cylindrical shaft, and two extremities. The upper end is articulated with the scapula, and the lower, which is divided into two articular surfaces, is articular with the two lines of the fore-arm.

The *Ulna* and *Radius* are articulated with the humerus above, and the carpal bones below. The ulna is the more slender bone. Its upper end forms the principal articulation of the elbow. Its lower extremity terminates in a small round head, to the inner side of which the radius is articulated. The radius is the rotary bone of the fore-arm, and by turning on the

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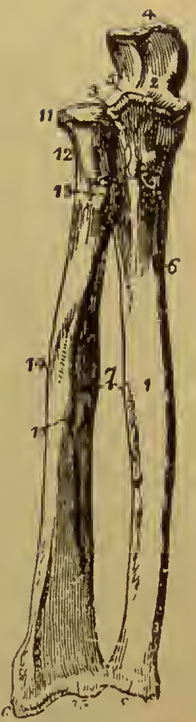
What bones does the upper extremity comprise? What are the shoulder bones? What are the bones of the arm?

Fig. 60.

The Humerus.

Fig. 60, is a front view of the humerus of the right arm. 1. Shaft 2. Head. 3. Neck. 4. Greater tuberosity. 5. Lesser tuberosity. 6. Bicipital groove. 7, 8. Bicipital ridges. 9. Rough surface for the attachment of the deltoid muscle. 10. A foramen for nutrient vessels. 11. Eminentia capitata. 12. Trochlea. 13. External condyle. 14. Internal condyle. 15. 16. Condyloid ridges. 17. Fossa for receiving the coracoid process of the ulna.

Fig. 61.



Ulna and Radius

ulna at the wrist, enables the hand to perform the motions of pronation and supination.

Fig. 61 is a front view of the ulna and radius. 1. Shaft of Ulna. 2. Greater sigmoid notch. 3. Lesser sigmoid notch. 4. Olecranon process. 5. Coracoid process. 6. Nutritive foramen. 7. Ridges to which the interosseous membrane is attached. 8. Capitulum ulnæ. 9. Styloid process. 10. Shaft of radius. 11. Its head. 12. Its neck. 13. Its tuberosity. 14. The oblique line. 15. Lower extremity. 16. Its styloid process.

BONES OF THE WRIST.

The eight bones of the wrist are arranged in two rows, constituting the *Carpus*. They are all seen in Fig. 62, which represents the outside of the right hand.

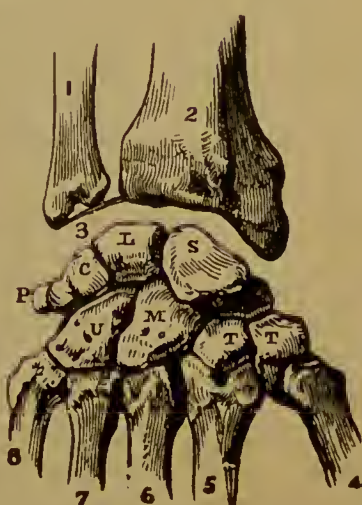


Fig. 62.—The Carpus.

1. Lower end of the radius. 2. Lower end of the ulna. 3. Intercarticular cartilages, attached to the styloid process of the ulna, and to the margin of the articular surface of the radius. S. The scaphoid. L. Semilunar. C. Cuneiform. P, Pisiform. T. Trapezium. T. Trapezoides. M. Os magnum. U. Unciform.

BONES OF THE HAND.

These are divisible into the five long hand bones, constituting the

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What motions are performed at the wrist? How many bones constitute the carpus? What are their names?

Metacarpus, and the fourteen bones of the fingers and thumb, termed *Phalanges*.

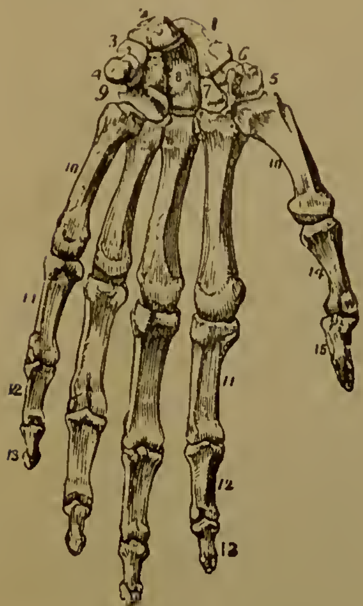


Fig. 63.—Metacarpus and Phalanges.

BONES OF THE LOWER EXTREMITY.

The lower extremity comprises:

The Femur,—thigh bone, .	1
The Patella,—knee bone, .	1
The Tibia and Fibula,—leg bones.	2
The Tarsus,—ankle bones, .	7
The Metatarsus,—foot bones,	5
The Phalanges,—toe bones, .	14

Fig. 63 represents the aspect of the bones of the hand anteriorly. 1. The scaphoid bone. 2. Semilunar. 3. Cuneiform. 4. Pisiform. 5. Trapezium. 6. A groove in the trapezium which lodges the tendon of the flexor carpi radialis muscle. 7. Trapezoides. 8. Os Magnum. 9. Unciform. 10, 10. The metacarpal bones. 11, 11. First row of phalanges. 12, 12. Second row. 13, 13. Third row. 14. First phalanx of the thumb. 15. second do.

Fig. 64.

Os Femoris.

BONES OF THE THIGH AND LEG.

The *Femur* is the longest bone in the body. Its different parts are seen in Fig. 64, which is a representation of the right femur as seen anteriorly.

1. The shaft. 2. Head. 3. Neck. 4. Great trochanter. 5. Anterior intertrochanteric line. 6. Lesser trochanter. 7. External condyle. 8. Internal condyle. 9. The tuberosity to which the external lateral ligament is attached. 10. The fossa for the tendon of the origin of the popliteal muscle. 11. The tuberosity for the internal lateral ligament.

The *Patella* (knee-pan) is one of the sesamoid bones, being developed in the tendon of the *quadriceps extensor* muscle. It is articulated with the condyles of the femur.

What constitutes the metacarpus? What the phalanges? The thigh? The knee-pan?

The *Tibia* and *Fibula* connect the thigh bone with the ankle. The tibia is the inner, and larger. The different parts of each are represented in Fig. 65, which is a front view as they are articulated with each other.

FIG. 65.

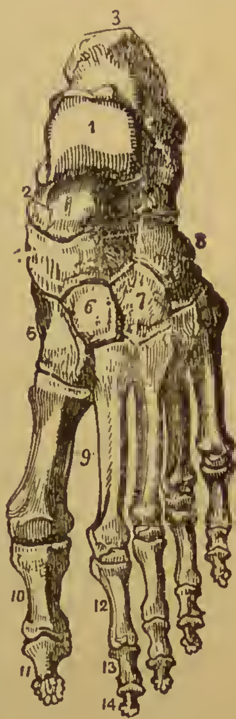
TIBIA AND FIBULA

FIG. 65.—1. Shaft of tibia. 2. Inner tuberosity. 3. Outer tuberosity. 4. Spinous process. 5. The tubercle. 6. Internal or subcutaneous surface of the shaft. 7. Lower extremity of the tibia. 8. Internal malleolus. 9. Shaft of the fibula. 10. Its upper extremity. 11. Its lower extremity, termed externa malleolus, the internal surface of which is articulated with the astragalus.

BONES OF THE ANKLE AND FOOT.

The arrangement of all the tarsal, metatarsal, and phalangeal bones of the lower extremity is shown in Fig. 66, which is a representation of the tarsal surface of the left foot.

FIG. 66.



BONES OF THE FOOT

FIG. 66.—1. Astragalus, its superior quadrilateral articular surface. 2. The anterior extremity of the astragalus, which articulates with the scaphoid. 3. Os calcis. 4. Scaphoid. 5. Internal cuneiform. 6. Middle cuneiform. 7. External cuneiform. 8. Cuboid. 9. Metatarsal bones of the first and second toes. 10. First phalanx of the great toe. 11. Second do 12. First phalanx of second toe. 13. Second do. 14. Third do.

Into the *calcaneous* or heel bone "*os calcis*), the *tendo achillis*, or strong tendon of the heel is inserted. It is sometimes ruptured in jumping and other violent exercises.

SESAMOID BONES.

These are small osseous masses, formed in tendons, which serve to protect neighboring parts from injurious friction. They constitute a sort of pulley for the tendons to play upon. The

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What are the leg bones? What bones constitute the foot? What are sesamoid bones?

patella is a sesamoid bone. Besides this there are four pairs properly belonging to the skeleton, two of which are situated on the metacarpo-phalangeal articulation of each thumb, and two upon the corresponding joint of the great toe. These bones are occasionally found on other joints. The bones of the ear are sesamoid.

What kind of a bone is the patella? How many sesamoid bones belong to the skeleton? Where are they situated?

CHAPTER VI.

THE LIGAMENTS—SYNDESMOLOGY.

THE connection between any two bones constitutes a joint, or articulation. In movable joints the opposing surfaces are coated by an elastic substance, called *cartilage;* this is lubricated by a fluid, called *synovia*, secreted by an enclosing membrane, called *synovial;* while the bones are firmly held together by bands of glistening fibres, called *ligaments.*

The *forms* of articulation are divided into three classes. 1. *Synarthrosis*, or fixed joint, as in the skull, upper jaw, vomer, and teeth. 2. *Diarthrosis*, or movable, the shoulder, hip, elbow, wrist, knee, ankle, carpus, and tarsus. 3. *Amphi-arthrosus*, or intermediate, as in the bodies of the vertebræ.

The *motions* of joints are of four kinds. 1. *Gliding*, the sliding motion of one articular surface upon another. It exists, to some extent, in all joints, and is the only motion in the carpus and tarsus. 2. *Angular*, which may be forward, called *flexion*, backward, called *extension;* inward, called *adduction;* or outward, called *abduction.* Flexion and extension are illustrated in the knee and elbow, and, more or less, in most other joints; adduction and abduction are seen complete in the shoulder, hip, and thumb. 3. *Circumduction*, which consists in a slight motion of the head of a bone, while the extremity is made to describe a large circle, as in the hip and shoulder. 4. *Rotation*, the movement of a bone on its own axis, as with the radius, the atlas upon the axis, and in the hip and shoulder.

The *structures* in the formation of a joint, in addition to the bone, are cartilage, fibrous tissue, adipose tissue, and synovial membrane.

The *cartilage* of joints serves not only to connect different bones, but also as a separating medium. It forms a thin coat

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What constitutes a joint? What is synovia? What are ligaments? What are the forms of joints? Motions? Structures?

ing tc the articular surface, and has been classed into *true*, *reticular*, and *fibrous*.

Fibrous tissue about the joints exists in the form of ligament, sometimes constituting bands of various breadth and thickness, and sometimes layers, which extend around the joints; these are called *capsular ligaments.*

Adipose tissue is found in greater or less quantities about joints, where it serves to fill up vacant spaces, and probably increase their elasticity.

Synovial membrane is the smooth, polished lining of a joint which secretes the synovia, and enables opposing surfaces to move upon each other with the most perfect ease and freedom.

Fig. 67.—Fibrous Cartilage.

In Fig. 67 is seen a portion of fibrous cartilage, largely magnified. Its development has already been described; the different kinds of cartilaginous structure are owing to subsequent changes in the cells and intercellular substance.

PARTICULAR ARTICULATIONS.

The connecting media of joints are generally named from some prominent circumstance in relation to form, position, points of connection, etc., as *capsular*, surrounding: *transverse*, running across; *occipito-axoid*, attached to and holding together the occipital and axis bones; *lateral*, connecting the sides of articulating bones, etc.; hence, except with the most important ligaments, the name will be a sufficient description.

The Vertebral Joints.—The vertebræ are held together by the following ligaments: 1. *Intervertebral substance*, a disc of fibrous cartilage interposed between the bodies of all the vertebræ. This varies in thickness in different parts of the column,

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What is the use of cartilage? Where is adipose tissue found? What is synovial membrane?

which circumstance contributes much to the formation of the vertebral curves. 2. *Anterior common ligament*, a broad, thin band of fibres attached to the bodies of the vertebræ in front, and extending along the whole column from the neck to the sacrum. 3. *Posterior common ligament*, attached to the bodies behind in a similar manner. 4. *Ligamenta subflava*, two thin plates of yellow fibrous tissue, situated between the arches. 5. *Capsular ligaments*, loose synovial membranes surrounding the articular processes. 6. *Inter-spinous ligaments*, thin membranous bands extended between the spinous processes in the dorsal and lumbar regions. 7. *Supra-spinous ligament*, a strong. inelastic fibrous cord, extending from the apex of the spinous process of the last cervical vertebra to the sacrum, being attached in its course to each spinous process. 8. *Inter-transverse ligaments*, connecting only the transverse processes of the lower dorsal vertebræ.

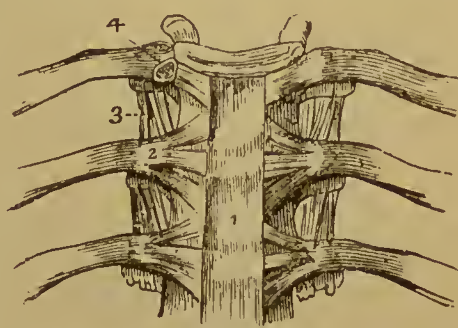

FIG. 68.—VERTEBRAL LIGAMENTS.

The connection of the anterior ligaments and those of the ribs is seen in Fig. 68. 1. Anterior common ligament. 2. Anterior costo-vertebral ligament. 3. Anterior costo-transverse ligament. 4. Interarticular ligament connecting the head of the rib to the intervertebral substance, and separating the two synovial membranes of this articulation.

THE NECK JOINT.—There are seven ligaments connecting the atlas with the os occipitis: Two *anterior ligaments*, one of which is a *rounded* cord, attached above to the base of the occipital, and below to the anterior tubercle of the atlas; the other is a *broad* membranous layer, lying deeper, attached to the margin of the occipital foramen above, and to the whole length of the anterior arch of the atlas below; a *posterior ligament*, thin and membranous, attached above to the margin of the occipital foramen, and below to the posterior arch of the atlas; two *lateral ligaments*, strong fascicula of fibres, attached below to the base of the transverse process of the atlas, at each side and above to the transverse process of the occipital bone; two *capsular lig-*

What ligaments connect the vertebræ? What ligaments are concerned in the neck-joint?

aments, thin ligamentous capsules surrounding the synovial membranes of the articulation, between the condyles of the occipital bone and the superior articular processes of the atlas. The motions between the cranium and atlas are *flexion* and *extension*.

The axis is articulated with the occipital bone by three ligaments—the *occipito-axoid*, a broad band covering the odontoid process and its ligaments, and two *odontoid*, short, thick fibrous fasciculi, which pass outward from the apex of the odontoid process to the sides of the occipital foramen and condyles. These ligaments are called *check* ligaments, because they limit the rotatory movements of the head.

The atlas is articulated with the axis by five ligaments. The *anterior* consists of ligamentous fibres, passing from the anterior tubercle and arch of the atlas to the base of the odontoid process and body of the axis. The *posterior* is a thin membranous layer, which passes between the posterior arch of the atlas and the laminæ of the axis. The two *capsular* loosely surround the articular processes of the atlas and axis, and permit great freedom of movement. The *transverse* is a strong band, arching across the area of the ring of the atlas, from one articular process to the other. It retains the odontoid process of the axis in connection with the anterior arch of the atlas. Where it crosses the odontoid process, some fibres pass downward to be attached to the body of the axis, and others are sent upward to the basilar process of the occipital bone. This disposition

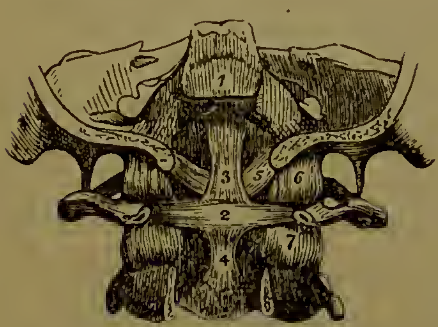

Fig. 69.—Neck Joint Posteriorly.

Fig 69 is a posterior view of the ligaments connecting the atlas, axis and occipitis. The back part of the occipitis and the arches of the atlas and axis have been removed. 1. The superior part of the occipito-axoid ligament, which has been cut away to show the ligaments beneath. 2. Transverse ligament of the atlas. 3, 4. Ascending and descending slips of the transverse ligament, which have given to it the title of *cruciform*. 5. One of the odontoid ligaments; the other is seen on the opposite side. 6. One of the occipito-atloid capsular ligaments. 7. One of the atlo-axoid capsular ligaments.

What ligaments connect the axis and occipitis? How are the atlas and axis articulated?

enables the atlas, and with it the whole head, to rotate upon the axis, its extent of rotation being limited by the odontoid ligaments.

Joints of the Lower Jaw.—These are formed by the *external lateral ligaments*, short, thick bands of fibres extending obliquely backward from the zygomas to the external surface of the necks of the lower jaw; the *capsular ligament*, consisting of a few irregular fibres passing from the edges of the glenoid cavities to the necks; the *inter-articular fibrous cartilages*, thin, oval plates, thicker at the edges than in the centre, placed hori. zontally between the heads of the condyles and the glenoid cavities, thus dividing each joint into an upper and a lower cavity; and the *synovial membranes*, one situated above and one below the cartilages.

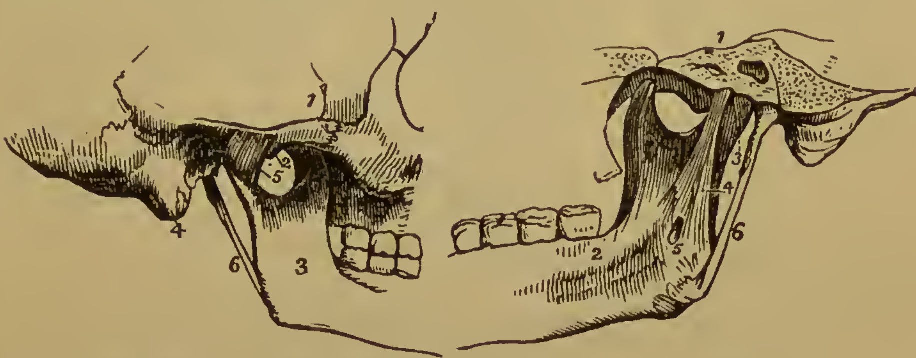

Fig. 70. Joints of the Lower Jaw. Fig. 71.

Fig. 70 is an external view of this articulation. 1. The zygomatic arch. 2. Tubercle of the zygoma. 3. Ramus of the lower jaw. 4. Mastoid portion of the temporal bone. 5. External lateral ligament. 6. Stylo-maxillary ligament.

Fig. 71 is an internal view. 1. A section through the petrous portion of the temporal bone, and spinous process of the sphenoid. 2. An internal view of the ramus and part of the body of the lower jaw. 3. Internal portion of the capsular ligament. 4. Internal lateral ligament. 5. A small opening at its insertion, where the milo-hyoidean nerve passes. 6. Stylo-maxillary ligament.

The movements of the lower jaw are *depression* and *elevation*, by which the mouth is opened and shut; also a *forward*, *backward*, and *lateral* movement from side to side, constituting the *grinding* motion.

The Costo-Vertebral Joints.—The ribs have a double ar-

What ligaments form the joint of the lower jaw? What are the movements of the lower jaw?

ticular connection with the vertebræ. 1. By ligaments connecting the *head of the rib* with the *bodies of the vertebræ.* 2. Those connecting the *neck* and *tubercle of the rib* with the *transverse processes* of the vertebræ. This arrangement renders dislocation impossible, as the neck of the rib would break before dislocation could occur. In addition, most of these costo-vertebral articulations have a *capsular*, *interarticular*, and three *transverse ligaments*, named, from their positions *anterior*, *middle*, and *posterior costo-transverse ligaments.*

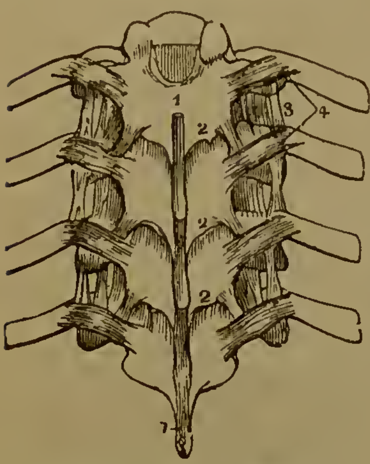

FIG. 72.—COSTO-VERTEBRAL JOINTS.

Fig 72 is a posterior view of a part of the thoracic portion of the vertebral column, showing the ligaments connecting the vertebræ with each other, and the ribs with the vertebræ. 1, 1. The supraspinous ligament. 2, 2. Ligamenta subflava, connecting the laminæ. 3. Anterior costo-transverse ligament. 4. Posterior costo-transverse ligaments.

The movement of these articulations are *upward* and *downward*, and slightly *backward* and *forward*, all the movements increasing from the head to the anterior extremity of the rib.

COSTO-STERNAL JOINTS. —In front the ribs are articulated with the sternum, and some of them with each other. Th' ligamentous connections are the *anterior*, *posterior*, *superio.* and *inferior costo-sternal*, and the *synovial membranes.* The *sixth*, *seventh*, *eighth*, and sometimes the *fifth* and *ninth* costal cartilages have a perfect synovial membrane, and articulate with each other.

The motions of these articulations are limited to a slight sliding movement.

JOINTS OF THE STERNUM.—The pieces of this bone are connected by a thin plate of *interosseous ligament*, and *anterior* and *posterior sternal ligaments*, which contribute very much to its strength, and to the elasticity of the front of the chest.

VERTEBRO-PELVIC JOINT.—The last lumbar vertebræ and the sacrum are connected by the same general ligaments as are

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What ligaments connect the ribs and vertebræ? Ribs and Sternum? Joints of the Sternum?

the vertebræ with each other; in addition to which there are two proper ligaments, called *lumbo-sacral* and *lumbo-iliac*.

Joints of the Pelvis.—There are four articulations of the pelvic bones. 1. *Sacro-iliac*, the connection of which is formed by an *anterior* and *posterior sacro-iliac ligament*. The latter is also called *inter-osseous*; it is composed of strong fibres passing horizontally between the rough surfaces of the sacro-iliac articulations. 2. *Sacro-ischiatic*, the union of the sacrum and ischium, formed by the *anterior* and *posterior sacro-ischiatic ligaments*. The upper border of the anterior forms part of the boundary of the *great sacro-ischiatic foramen;* and its lower border a part of the *lesser sacro-ischiatic foramen*. The superior border of the posterior forms also a part of the lesser sacro-ischiatic foramen, and its lower border a part of the boundary of the perineum. The two ligaments convert the sacro-ischiatic notches into foramina.

Sacro-Coccygean Joint.—Between the sacrum and coccyx is a soft fibrous cartilage. The bones are held together also by the *anterior* and *posterior sacro-coccygean ligaments*. This articulation admits of a backward motion during parturition.

Pubic Joint.—The ossa pubis are connected together by an *inter-osseous cartilage*, the *anterior*, *posterior*, *superior* and *sub-pubic ligaments*, which variously cross the symphisis, or place of union. The articulation becomes movable during parturition, and admits of a slight separation of the bones.

The numerous vacuities in the walls of the pelvis, and their closure by ligamentous structures, diminish materially the pressure on the soft parts during the passage of the head of the fœtus.

Note.—The *obturator ligament* or *membrane* is a tendo-fibrous expansion stretched across the obturator foramen. It is not concerned in articulation, but gives attachment to the obturator muscles, and leaves a space in the upper part of the foramen for the passage of the obturator vessels and nerves.

Sterno-Clavicular Joints.—The breast and collar bones are connected by the *anterior*, *posterior*, *sterno-clavicular*, *inter-clavicular*, and *costo-clavicular ligaments*, an *inter-articular car-*

What are the pelvic joints? Sacro-coccygean? Pubic? Sterno-clavicular?

tilage, and two synovial membranes. The motions of this artic ulation are *gliding* and *circumduction.* This joint is the centre of the movements of the shoulder. In dislocations of thes ter- nal end of the clavicle, the costo-clavicular ligament, call- ed also *rhomboid*, is ruptured, occasioning a peculiar defor- mity.

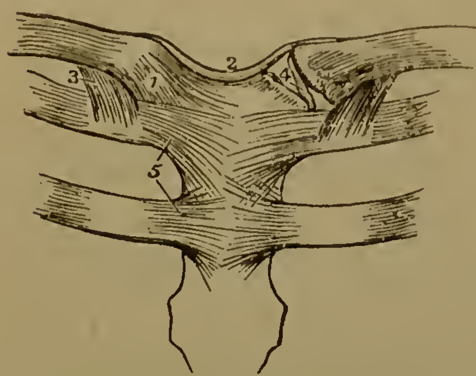

FIG. 73.—STERNO-CLAVICULAR JOINT.

Fig. 73 shows the ligaments of the ster- no-clavicular and costo-sternal articu- lations. 1. Anterior sterno-clavicular ligament. 2. Inter-clavicular ligament. 3. Costo-clavicular. 4. Inter-articular cartilage. 5. Anterior costo-sternal ligaments of the first and second ribs.

SCAPULO-CLAVICULAR JOINT.—The shoulder-blade and breast bone are connected by *two synovial membranes*, an *inter-articu- lar cartilage*, a *superior acromio-clavicular*, an *inferior acromio clavicular*, and a *coraco-clavicular ligament.* This articulation ad- mits of a *gliding* and *rotatory* movement.

NOTE.—The shoulder-blade has two ligaments, *coraco-acromial* and *transverse*, which are proper to itself. The first is a thick triangular band, forming a protecting arch over the shoulder joint. The second crosses the notch in its upper border, thus converting it into a foramen.

FIG. 74.—SHOULDER-JOINT.

The ligaments of the scapula and shoulder joint are seen in Fig. 74. 1. Superior acromio-clavi- cular. 2. Coraco-clavicular. 3. Coraco-acro- mial. 4. Transverse. 5. Capsular. 6. Coraco- humeral. 7. The long tendon of the biceps muscle issuing from the capsular ligament, and entering the bicipital groove.

THE SHOULDER-JOINT.—The sca- pula and humerus form a ball-and-

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How are the scapula and Sternum connected? What kind of a joint is that of the shoulder?

socket articulation; its ligaments are the *capsular*, *coraco-humeral*, and *glenoid*.

The *capsular ligament* encircles the heads of the scapula and humerus. The *coraco-humeral* is a broad band between the coracoid process of the scapula and the greater tuberosity of the humerus. The *glenoid* is a cartilaginous band around the margin of the glenoid cavity, which it deepens.

The synovial membrane of this joint is very extensive, and the articulation admits of every kind of motion.

THE ELBOW JOINT.—At this articulation the humerus, ulna, and radius are connected by four ligaments in addition to its *synovial membrane.* They are the *anterior*, composed of fibres, which pass vertically, transversely, and obliquely, forming a broad membranous layer, between the anterior surface of the humerus and the coronoid process of the ulna and orbicular ligament; the *posterior*, a broad loose layer between the posterior surface of the humerus and the olecranon; the *internal lateral*, a thick triangular layer passing between the inner condyle of the humerus to the margin of the greater sigmoid cavity of the ulna; and the *external lateral*, a strong narrow band descending from the external condyle of the humerus to the orbicular ligament and ridge of the ulna.

FIG. 75.

ELBOW JOINT INTERNALLY.

An internal view of the ligaments is seen in Fig. 75. 1. Anterior. 2. Internal lateral. 3. Orbicular. 4. Oblique. 5. Inter-osseous. 6. Internal condyle of the humerus, which conceals the posterior ligament.

The motions of this articulation are *flexion* and *extension*, the former being limited by the coronoid process, and the latter by the olecranon.

RADIO-ULNAR JOINT.—The radius and ulna are held together by an *inter-articular cartilage*, the lower surface of which enters into the articulation of the wrist; the *orbicular ligament*, which surrounds the head of the radius, and is attached at each end

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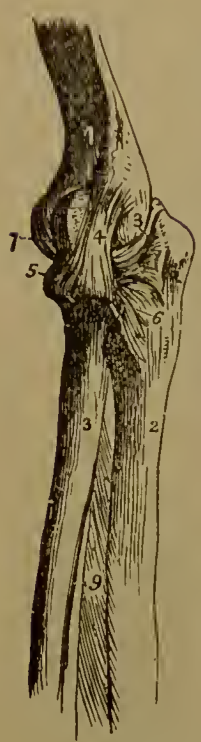
How is the elbow joint formed? What are its motions? How are the bones of the forearm connected?

Fig. 76.



Elbow Joint Externally.

to the extremities of the lesser sigmoid cavity, the *oblique ligament*, a narrow slip between the coronoid process and the inner side of the radius; the *inter-osseous ligament*, a broad aponeurosis between the ridges of the radius and ulna; and the *anterior inferior* and *posterior inferior ligaments.* The orbicular ligament is necessarily ruptured in dislocations of the head of the radius.

Fig. 76 is an external view of the elbow articulation. 1. Humerus. 2. Ulna. 3. Radius. 4, External lateral ligament inserted below into the orbicular (5.) 6. The posterior extremity of the orbicular, spreading out at its insertion into the ulna. 7. Anterior ligament. 8. Posterior ligament.

The lower part of the inter-osseous ligament is perforated for the passage of the anterior inter-osseous artery. The posterior inter-osseous artery passes backward between the oblique ligament and the upper border of the inter-osseous ligament. This ligament affords an extensive surface for the attachment of muscles.

The movements of this joint are, the rotation of the radius upon the ulna; the forward rotation is called *pronation*, and the backward *supination.* The head of the radius also turns upon its own axis within the orbicular ligament and the lesser sigmoid notch of the ulna; and inferiorly a concavity in the radius moves on the rounded head of the ulna.

The anterior and posterior inferior ligaments are chiefly concerned in limiting the movements of the radius, and hence, in great muscular efforts, are frequently ruptured.

The Wrist Joint.—This articulation is formed by the *anterior*, *posterior*, *internal lateral* and *external lateral ligaments*, with the *synovial membrane.* Its motions are *flexion*, *extension*, *adduction*, *abduction*, and *circumduction*, in all of which movements the articular surfaces glide upon each other. The wrist joint is an example of the articulation called *ginglymoid.* The radial

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What are the movements of the elbow joint? How is the wrist joint formed?

artery rests on the external lateral ligament as it passes backward to the first metacarpal space.

The ligaments of the wrist and hand are seen anteriorly in Fig. 77. 1. Interosseous membrane. 2, Anterior inferior radio-ulnar ligament. 3. Anterior ligament of the wrist. 4. Its external lateral. 5. Its internal lateral. 6, Palmar ligaments of the carpus. 7. Pisiform bone, with its ligaments. 8. Ligaments connecting second range of carpal bones with the metacarpal, and these with each other. 9. Capsular ligaments of the carpo-metacarpal articulation of the thumb. 10. Anterior ligament of the metacarpo-phalangeal articulation of the thumb. 11. One of the lateral ligaments of that articulation. 12. Anterior ligament of the metacarpo-phalangeal articulation of the index finger. 13. Lateral ligaments of the same joint; the corresponding ligaments are seen in the other articulations. 14. Transverse ligament connecting the heads of the metacarpal bones of the index and middle fingers; the same ligament is seen between the other fingers. 15. Anterior and one lateral ligament of the phalangeal articulation of the thumb. 16. Anterior and lateral ligaments of the phalangeal articulations of the index finger; the anterior ligaments are removed in the other fingers.

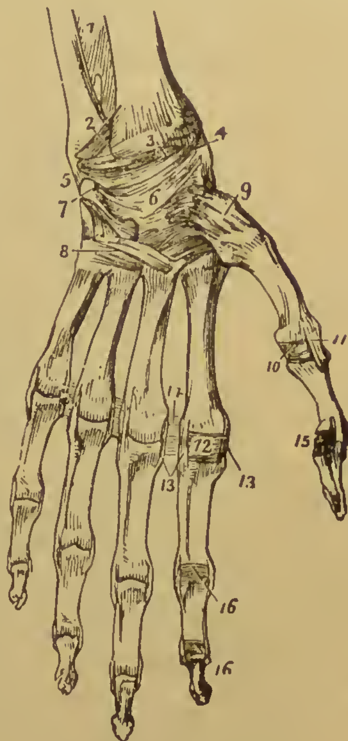

FIG. 77.—WRIST JOINT.

THE CARPAL JOINTS.—The carpal bones are connected by ligamentous bands, which pass transversely and longitudinally from bone to bone on the back, called *dorsal ligaments;* by *palmar ligaments*, which have a similar disposition in front; by *inter-osseous cartilages* between the bones; and by a strong ligamentous band connecting the bones of the two sides, called *anterior annular ligament.* Five distinct *synovial membranes* enter into carpal articulations.

Between the bones of each range there is a slight movement of *flexion* and *extension.*

THE CARPO-METACARPAL JOINTS.—The second row of carpal bones articulates with the metacarpal finger bones by *dorsal* and *palmar* ligaments; and the metacarpal of the thumb is joined to the trapezium by a true *capsular ligament.* The metacarpal bones of the four fingers are connected at their bases

How are the carpal bones connected? What motions between them? How are carpo-metacarpal joints formed?

by *dorsal*, *palmar* and *inter-osseous* ligaments. The thumb, shoulder, and hip joints are the only ones in the body having *true* capsular ligaments.

The movements of the carpo-metacarpal articulations are limited to a slight degree of *sliding* motion, except in the case of the metacarpal bone of the thumb with the trapezium, which has *flexion*, *extension*, *adduction*, *abduction*, and *circumduction*.

METACARPO-PHALANGEAL JOINTS.—The metacarpal and finger joints are united by *anterior* fibro-cartilaginous ligaments, strong, narrow *lateral* ligaments, and strong ligamentous bands, called *transverse* ligaments.

These articulations have the motions of *flexion*, *extension*, a limited *adduction* and *abduction*, and a slight degree of *circumduction*.

PHALANGEAL JOINTS.—The finger bones are connected by an *anterior* and two *lateral ligaments*. The extensor tendon performs the office of a posterior ligament, as with the preceding articulations.

The movements are *flexion* and *extension*.

THE HIP JOINT.—The head of the femur is received into the cup-shaped cavity of the acetabulum, forming a ball-and-socket joint. Its ligaments are the *capsular*, which embraces the acetabulum superiorly, and the neck of the femur inferiorly; the *ilio-femoral*, an accessory attachment to the anterior portion of the capsular; the *liga-*

FIG. 78.—PELVIS AND HIP ANTERIORLY.

The ligaments of the pelvis and hip joint are partly shown in Fig. 78. 1. Lower part of the anterior common ligament of the vertebræ, extending downward over the front of the sacrum. 2. Lumbo-sacral. 3. Lumbo-iliac. 4. Anterior sacro-iliac. 5. Obturator membrane. 6 Poupart's ligament. 7. Gimbernat's. 8. Capsular. 9. Ilio-femoral, or accessory.

What joints have *true* capsular ligaments? What are metacarpo-phalangea joints? Phalangeal?

mentum teres, which holds the centre of the head of the femur to the acetabulum; the *cotyloid*, a cartilaginous cord around the margin of the acetabulum, which cavity it serves to deepen; the *transverse*, extending across the notch of the acetabulum; and the *synovial membrane*, which invests the head of the femur, and spreads around the ligamentum teres.

A side view of the ligaments of the pelvis and hip joint is seen in Fig. 79. 1. Oblique sacro iliac. 2. Posterior sacro-ischiatic. 3. Anterior sacro-ischiatic, 4. Great sacro-ischiatic foramen. 5. Lesser sacro-ischiatic foramen. 6. Cotyloid ligament of the acetabulum. 7. Ligamentum teres. 8. Edge of the capsular. 9. Obturator membrane partly exhibited.

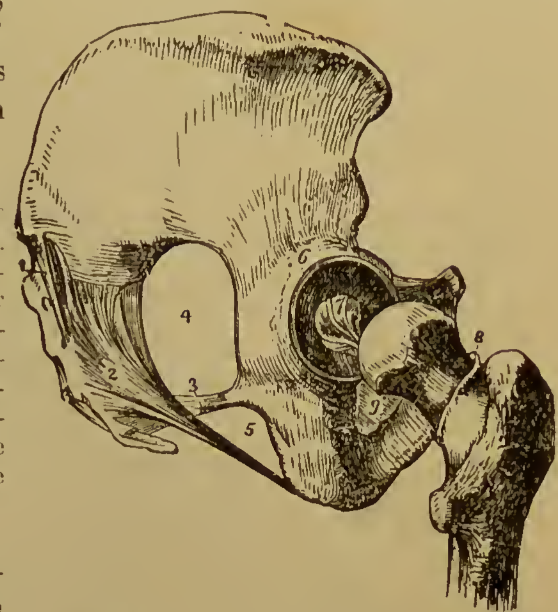

Fig. 79.—Pelvis and Hip Laterally.

The hip joint has an extensive range of movements —*flexion*, *extension*, *adduction*, *abduction*, *circumduction* and *rotation*.

The fossa at the bottom of the acetabulum is filled by an adipose mass, covered by synovial membrane, which serves as an elastic cushion to the head of the bone during its movements.

The Knee Joint.—The femur, tibia, and fibula, and the patella, are connected at the knee joint by thirteen ligaments; the first-named five are external, and the next five are internal to the articulation, and the remaining three are mere folds of synovial membrane.

The *anterior*, or *ligamentum patellæ*, is a prolongation of the tendon of the extensor muscles of the thigh downward to the tubercle of the tibia, enclosing the patella; the *posterior* is a broad expansion covering the whole back part of the joint; the *internal lateral* is a broad layer extending between the

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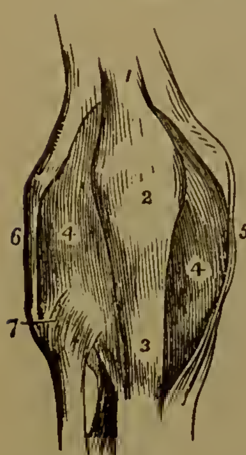
How is the hip joint formed? What are its motions? How is the knee joint formed?

internal condyle of the femur and the inner tuberosity of the tibia; the *two external lateral* connect the external condyle of the femur to the outer part of the head of the tibia, and the external semi-lunar cartilage of the articular surfaces with the fibula. Within the joint are the *anterior* and *posterior crucial*, which connect the head of the tibia with the condyles of the femur; the *transverse*, a slip of fibres extending between the semi-lunar and internal cartilages; the *coronary*, short fibres connecting the borders of the semi-lunar cartilages to the head of the tibia and surrounding ligaments.

FIG. 80.

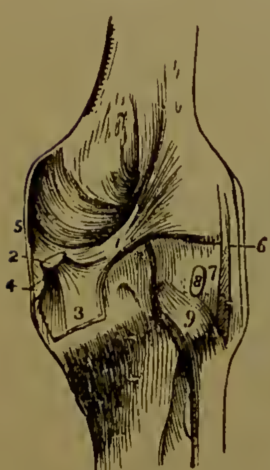


KNEE-JOINT ANTERIORLY.

Fig. 80 exhibits a front view of the ligaments. 1. The tendon of the quadriceps extensor muscle of the leg. 2. Patella. 3. Anterior ligament. 4. 4. Synovial membrane. 5. Internal lateral ligament. 6. The long division of the external lateral. 7. Anterior superior tibio-fibular ligament.

The *semi-lunar cartilages* are two falciform fibrous plates around the margin of the head of the tibia, serving to deepen the articular surface for the condyles of the femur.

FIG. 81.



KNEE-JOINT POSTERIORLY.

Fig. 81 gives a posterior view of the ligaments. 1. The fasciculus of the posterior ligament. 2. The tendon of the semi-membranous muscle, from which the posterior ligament is derived. 3. The process of the tendon which spreads out in the fascia of the popliteus muscle. 4. The process which is sent inward beneath the internal lateral ligament. 5. Posterior part of the internal lateral ligament. 6. The long division of the external lateral. 7. Its short division. 8. Tendon of the popliteus cut short. 9. Posterior superior tibio-fibular ligament.

The synovial membrane of this joint is the most extensive in the skeleton, investing the cartilaginous surfaces of the condyles of the femur, of the head of the tibia, and of the inner surface of the patella. Between it and the ligamentum patellæ is a mass of fatty substance, which presses the membrane

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What is the function of the semi-lunar cartilages? What is peculiar in the synovial membrane of the knee joint?

toward the interior of the joint, and occupies the fossæ between the condyles.

A slender, conical process of synovial membrane, called *ligamentum mucosum*, proceeds from the transverse ligament. Its apex is connected with the anterior part of the condyloid notch, and its base is lost in the mass of fat which projects into the joint beneath the patella. The *alar ligaments* are two fringed folds of synovial membrane, extending from the ligamentum mucosum along the edges of the mass of fat to the sides of the patella.

The movements of this joint are *flexion* and *extension*, with a slight degree of *rotation* when the knee is semi-flexed.

TIBIO-FIBULAR JOINTS.—The bones of the leg are firmly connected together at each extremity by five ligaments: the *interosseous*, *transverse*, *anterior* and *posterior*, to which is to b- added the *synovial membrane.*

The movements between these bones is a very slight degree of yielding or *sliding* motion.

FIG. 82.

ANKLE-JOINT EXTERNALLY.

Fig. 82 is an external view of the ankle articulation. 1. Tibia. 2. External malleolus of the fibula. 3, 3. Astragalus. 4. Os calcis. 5. Cuboid. 6. Anterior fasciculus of the external lateral ligament attached to the astragalus. 7. Its middle fasciculus attached to the calcis. 8. Its posterior fasciculus attached to the astragalus. 9. Anterior ligament.

THE ANKLE-JOINT.—This is formed by the tibia and fibula with their malleolar processes above, and the astragalus below, connected by three ligaments: the *anterior*, a thin membranous layer; the *internal lateral*, or *deltoid*, a triangular layer of fibres attached above to the internal malleolus, and below to the astragalus, calcis, and scaphoid; and the *external lateral*, which consists of three separate bundles of fibres, proceeding from the external malleolus, the anterior of which is attached to the astragalus, the *posterior* to the back part of the same bone, and the *middle* to

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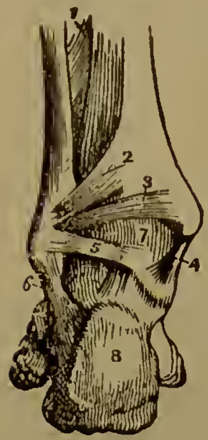
What movements of the knee joint? How are the tibio-fibular joints formed? How is the ankle-joint formed?

the outer side of the os calcis. The motions of this joint are *flexion* and *extension*.

Fig. 83.



Ankle Joint Posteriorly.

Fig. 83 is a posterior view of the ankle joint. 1. Lower part of the inter-osseous membrane. 2. Posterior inferior ligament connecting the tibia and fibula. 3. Transverse ligament. 4. Internal lateral. 5. Posterior fasciculus of the internal lateral. 6. Middle fasciculus of the external lateral. 7. Synovial membrane. 8. Os calcis.

The Tarsal Joints.—The bones of the tarsus are connected by *dorsal* ligaments, which pass from each bone to all others contiguous: the *plantar*, which connect their under surfaces similarly, and the *inter-osseous*, of which there are five, situated between adjoining bones. These articulations admit of a slight degree of motion —*forward*, *backward*, and *laterally;* and between the first and second range of bones *adduction* and *abduction*, with slight *flexion* and *extension*, take place.

Fig. 84.

Sole of the Foot.

The ligaments of the sole of the foot are seen in Fig. 84. 1. Os calcis. 2. Astragalus. 3. Tuberosity of the scaphoid. 4. Long calcaneo-cuboid ligament. 5. Part of the short calcaneo-cuboid. 6. Calcaneo-scaphoid. 7. Plantar tarsal. 8. 8. Tendon of the peroneus-longus muscle. 9. 9. Plantar tarso metatarsal ligaments. 10. Plantar ligament of the metatarso-phalangeal joint of the great toe; the same ligament is seen upon the other toes. 11. Lateral ligaments of the metatarso-phalangeal joint. 12. Transverse ligament. 13. Lateral ligaments of the phalanges of the great toe; the same ligaments are seen upon the other toes.

Tarso-Metatarsal Joints.—The ligaments connecting the tarsal and metatarsal bones are also *dorsal*, *plantar*, and *inter-osseous*. The *synovial membranes* are three. The only motion is a slight *yielding* to pressure.

Metatarso-Phalangeal Joints.—The bones of the metatarsus are connected with those of the toes by ligaments, called *plantar*, *lateral*, and *transverse*, so arranged as to admit of *flexion*, *extension*,

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How are the tarsal joints formed? Tarso-metatarsal? Metatarso-phalangeal?

adduction and *abduction*. The expansion of the extensor tendon supplies the place of a dorsal ligament.

THE TOE JOINTS.—The phalanges of the toes have the same ligamentous connection as those of the fingers, and the same variety and extent of motion.

NOTE.—In amputations of the tarso-metatarsal joint, it must be understood that the metatarsal bone of the second toe is strongly wedged between the internal and external cuneiform bones, being the most firmly articulated of all the metatarsal bones.

What are the motions of the metatarso-phalangeal joints? How are the toe joints formed?

CHAPTER VII.

MYOLOGY.

MYOLOGY is the subject or doctrine of the muscles. The muscles, which constitute the flesh proper of all animals, and of man, are the *motory organs.* Their actions perform all the motions of the body. The muscles are much more numerous in some of the smaller animals than in man; even the caterpillar insect has several thousands, while man has but a few hundreds.

It is by the alternate contraction and relaxation of the muscular fibres that all functional motions are performed within the living domain, all locomotion by which the body moves from one place or position to another, and by which the thoughts and feelings of the soul or spirit are manifested in the expressions of the face. The arrangement of the muscles of the human face (Fig. 85) admit, as will be seen at a glance, of motion in any or all parts of the face, and in all possible directions. This is why the unconstrained action of the muscles of the face are so true to the ideas and emotions of the mental organs, that the child and the young animal, never err in interpreting one's disposition towards them by looking him in the face. It is true, that education and training enable us, in a great measure, to control the action of the muscles of the face by will power, and so disguise our intentions and sentiments as to deceive others. Those, therefore, who would fully understand the subject, must study expression in the faces of animals and unsophisticated young children.

Few persons, if any, who have represented Shakespeare's great characters on the stage, ever had a greater command of the muscles of expression than Madame Rachel; yet no person, in

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What is myology? How are functional motions performed? What is peculiar in the muscles of the face.

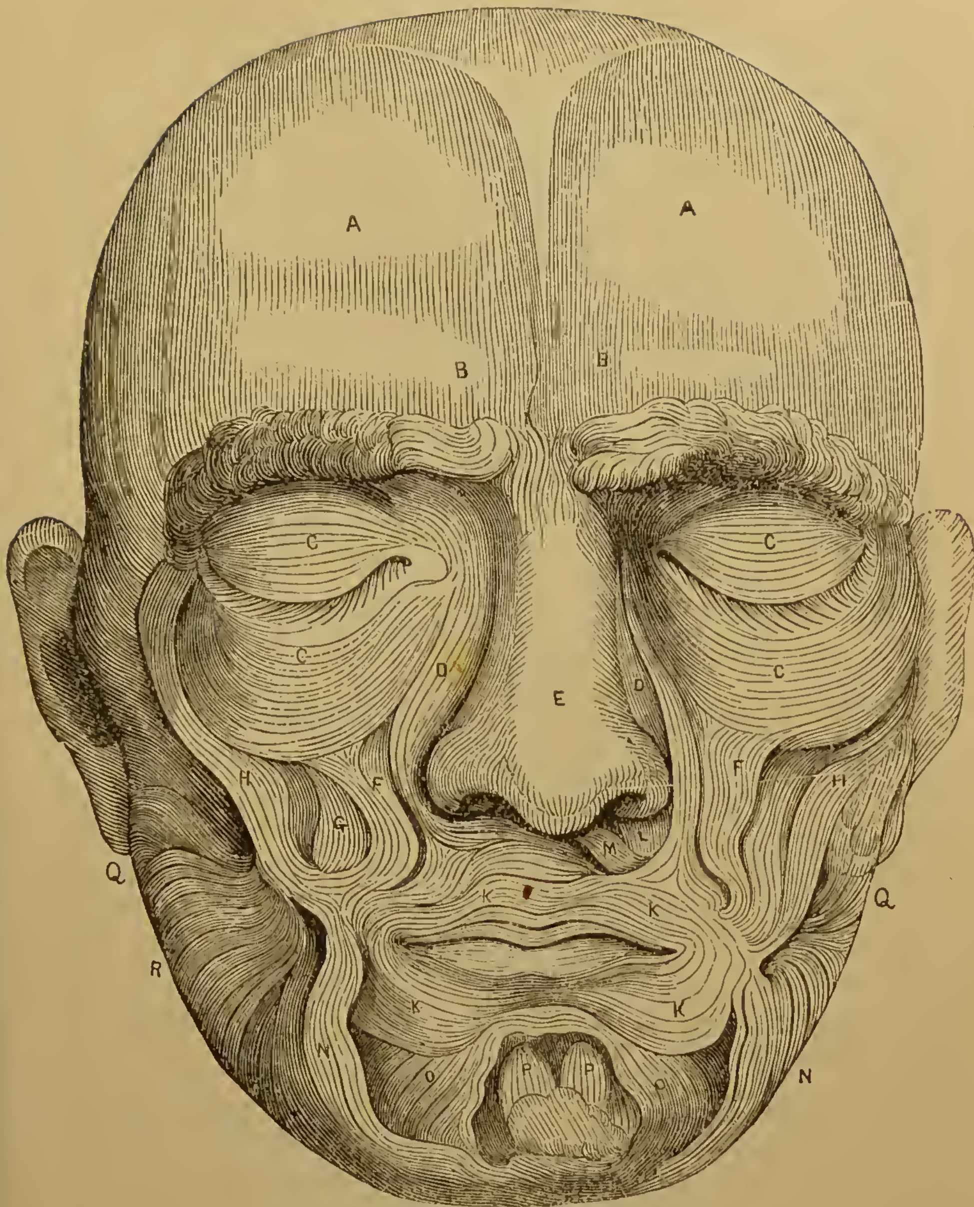


FIG. 85.—MUSCLES OF THE FACE.

A, A, B, B.—Occipito Frontalis, the broad muscle of the forehead. The light shades show its tendinous expansions, and the dark lines its fleshy fibres. C, C, C, C. Orbicularis Palpebrarum, the circular muscle of the eyelids. D, D. Compressor nares, the compressing muscles of the nostrils. E. Bridge of the nose. F, F. Levator Labii Superioris, the muscle that raises the upper lip. H, H. Zygomatic Major, which elevates angle of the mouth. K, K, K, K. Orbicularis Oris, the round muscle of the mouth. M. Depressor Alæ Nasi, which depresses the sides of the nostril. N, N Levator Menti, the muscles which elevate the chin. O, O. Depressor Anguli Oris, which pulls down the angle of the mouth. Q, Q. Risorius, which moves the mouth laterally. R. Buccinator, one of the chief muscles of mastication.

repose, could present a more placid and *expressionless* face. Fig. 86.

The muscles are composed of parallel fibres, of a deep red color, and usually termed *lean flesh*. These fibres are held together by a delicate web of *areolar tissue*, which becomes condensed and so modified toward the extremities of the muscles as to form glistening fibres and cords, called *tendons*, by which they are attached to the surface of the bones.

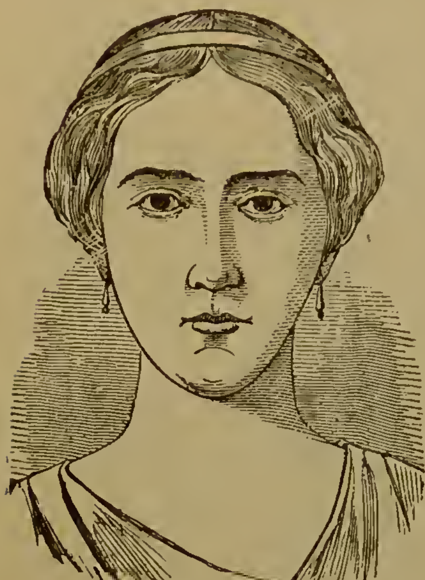


Fig. 86.—Rachel.

The greater portion of the bulk of the body is composed of muscular tissue. In the limbs the muscles invest and protect the bones and some of the joints. In the trunk they are spread out to enclose cavities, and form a defensive wall, capable of yielding to external pressure, and again returning to its original position. The tendons of broad muscles are often spread out, forming expansions called *aponeuroses*.

The *names* of muscles are generally derived from some prominent character in shape, structure, or use, or points of attachment. The more fixed or central point of attachment is called the *origin* of a muscle, and its movable extremity its *insertion*. Some muscles, however, pull equally at both extremities.

Structure of Muscle.—Muscular tissue is composed of bundles of fibres, of variable size, called *fasciculi*, enclosed in a cellular sheath. Each *fasciculus* is composed of smaller bundles, and each bundle of single fibres. These *ultimate fibres*, by microscopic examination, appear to be composed of still smaller fasciculi, called *ultimate fibrils*, enclosed in a delicate sheath, called *myolemma*. Anatomists distinguish two kinds of ultimate muscular fibre: that of voluntary, or animal life, and that of involuntary, or organic life.

Of what are muscles composed? What are tendons? Aponeuroses? What is the structure of muscular tissues? Kinds?

The *ultimate fibre of animal life* is distinguished by uniformity of calibre, by its longitudinal striæ, and by transverse markings, which occur at short regular distances. The *ultimate fibrils* are regarded as beaded filaments, consisting of a regular succession of segments and constrictions. An ultimate fibre is composed of a bundle of these fibrils, so disposed that all the segments and all the constrictions correspond, in this manner giving rise to alternate light and dark lines of the transverse striæ.

Fig. 87 represents an ultimate fibre of animal life, in which tbe transverse splitting into discs, in the direction of the constrictions of the ultimate fibrils, is seen.

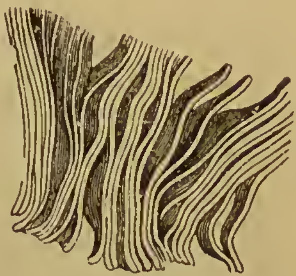


FIG. 87.—ULTIMATE FIBRE.

The *ultimate fibre of organic life* is a simple homogeneous filament, flat, without transverse markings, and much smaller than that of animal life. The fibres are collected into fasciculi of various sizes, and held together by dark nuclear fibres. Generally a dark line, or several dark points, may be seen in the interior of the organic fibres; and sometimes the fibre is enlarged at irregular distances; these appearances are owing to the presence of unobliterated nuclei of the cells from which the fibre was originally developed.

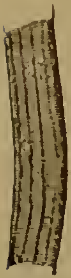
FIG. 88.—FIBRES.

In Fig. 88, 1 exhibits a muscular fibre of organic life from the bladder, magnified 600 times. Four of the nuclei are seen. 2 represents a fibre of organic life from the stomach, equally magnified.

DEVELOPMENT OF MUSCULAR FIBRE.—This is effected by the formation of nucleated cells out of an original *blastema*, or fluid substance capable of becoming organized, and the conversion of the cells into the tubuli of ultimate fibres, by the process already described in relation to the development of bone, while their contents are transformed into ultimate fibrils; in this way the cell membranes constitute the myolemma, and their contents a blastema, out of which new cells are formed.

How are ultimate fibres of animal life distinguished? Of organic life? How is muscular fibre developed?

FIG. 89. FIG. 90



DEVELOPMENT OF MUSCLE

Fig. 89, is a muscular fibre of animal life, enclosed in its myolemma The transverse and longitudinal striæ are seen. Fig 90. Muscular fibres of animal life, more highly magnified than the former. The myolemma is so thin and transparent that the ultimate fibrils can be seen through it. They show the nature of the longitudinal striæ, as well as the formation of the transverse striæ.

The *voluntary system*, or that of *animal life*, is developed from the external or serous layer of the germinal membrane, and comprehends all of the muscles of the limbs and trunk. The *involuntary*, or *organic system*, is formed from the internal or mucous layer, and constitutes the thin muscular structure of the alimentary canal, bladder, and internal organs of generation. At the commencement and termination of the alimentary canal, both classes of fibres are blended in the formation of the muscular coat. The heart is developed from the middle or vascular layer of germinal membrane, and is composed of ultimate fibres having the transverse striæ of the muscles of animal life, although its action is involuntary.

MUSCLES OF THE HEAD AND FACE.

These have been divided into eight groups—cranial, orbital, ocular, nasal, superior labal, inferior labal, maxillary, and auricular.

CRANIAL GROUP.—This has but one muscle, the *occipito frontal.* It is a broad expansion, covering the whole side of the vertex of the skull from the occiput to the eyebrow. It *arises* by tendinous fibres from the outer two-thirds of the upper curved line of the occipital, and from the mastoid process of the temporal bone. It is *inserted* above the orbit by means of a blending of its fibres with those of the orbicularis palpebrarum, corrugator supercilii, levator labii superioris alæque nasi, and pyramidalis nasi. Its *use* is to raise the eyebrows, in doing which the integuments of the forehead are wrinkled. In some persons the whole scalp moves by the contraction of this muscle.

THE ORBITAL GROUP.—Three muscles: 1. *Orbicularis palpebrarum*, a sphincter or closing muscle, which surrounds the

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Of what are voluntary muscles formed? Involuntary? What muscles constitute the cranial group? Orbital?

orbit and eyelids. 2. *Corrugator supercilii*, a narrow, pointed muscle, *arising* from the inner extremity of the superciliary ridge; *inserted* into the orbicularis palpebrarum. 3. *Tensor tarsi*, a very small muscle, *arising* from the orbital surface of the lachrymal bone; *inserted* by two slips into the lachrymal canals. The *use* of this group is to close the lids, draw the eyebrows downward and inward, and extend the lachrymal canals.

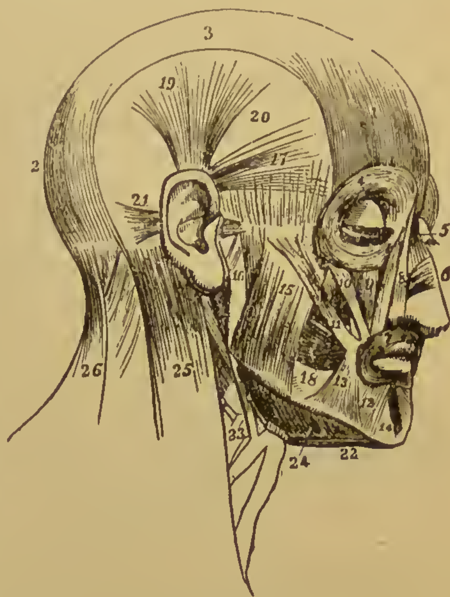

Fig. 91.—Muscles of the Head and Face.

Fig. 91 shows the muscles of the head and face. 1. Frontal portion of the occipito-frontalis. 2. Its occipital portion. 3. Its aponeurosis, or expansion. 4. Orbicularis palpebrarum, which conceals the corrugator supercilii and tensor tarsi. 5. Pyramidalis nasi. 6. Compressors nasi. 7. Orbicularis oris. 8. Levator labii superioris alæque nasi. 9. Levator labii superioris proprius; the lower part of the levator anguli oris is seen between 10 and 11. 10. Zygomaticus minor. 11. Zygomaticus major. 12. Depressor labii inferioris. 13. Depressor anguli oris. 14. Levator labii inferioris. 15. Superficial portion of the masseter. 16. Its deep portion. 17. Attrahens aurem. 18. The buccinator. 19. Attollens aurem. 20. Temporal fascia covering in the temporal muscle. 21. Retrahens aurem. 22. Anterior belly of the digastricus; its tendon is seen passing through its aponeurotic pulley. 23. Stylo-hyoid, pierced by the posterior belly of the digastricus. 24. Mylo-hyoidens. 25. Upper part of the sterno-mastoid. 26. Upper part of the trapezius. The splenius is seen between 25 and 56.

The Ocular Group.—This group consists of seven: 1. *Levator palpebræ*, long, thin, and triangular, situated in the upper part of the orbit; *arises* from the upper margin of the optic foramen and sheath of the optic nerve; *inserted* into the upper border of the upper tarsal cartilage. 2. *Rectus superior*, *arising* with the preceding; *inserted* into the globe of the eye about three lines from the margin of the cornea. 4. *Rectus internus*, a short, thick muscle; *arises* from the common tendon and the sheath of the optic nerve; *inserted* into the inner surface of the globe, near the margin of the cornea. 5. *Rectus externus; arises*

What are the muscles of the head and face called? What muscles constitute the ocular group?

from the common tendon, and from the margin of the optic foramen; *inserted* into the outer surface of the globe near the cornea. 6. *Obliquus superior; arises* from the margin of the optic foramen and sheath of the optic nerve; *inserted* into the sclerotic coat near the entrance of the optic nerve. 7. *Obliquus inferior; arises* from the inner margin of the superior maxillary bone; *inserted* into the outer and superior part of the eyeball, near the entrance of the optic nerve.

Uses.—The levator raises the upper eyelids; the four recti, when acting singly, pull the eyeball upward, downward, inward, and outward; the superior oblique rolls the globe inward and forward; the inferior oblique rolls the globe outward and backward.

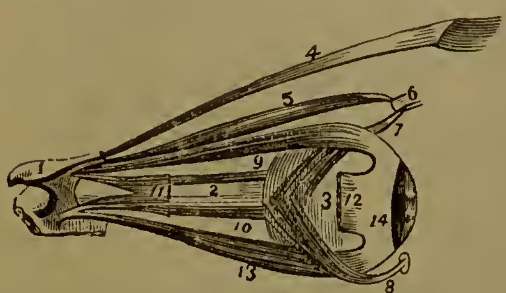

FIG. 92.—MUSCLES OF THE EYEBALL.

Fig. 92 is a view of the ocular group, taken from the outer side of the right orbit. 1. A small fragment of the sphenoid bone around the entrance of the optic nerve into the orbit. 2. Optic nerve. 3. Globe of the eye. 4. Levator palpebræ muscle. 5. Superior oblique. 6. Its cartilaginous pulley. 7. Its reflected tendon. 8. Inferior oblique. 9. Superior rectus. 10. Internal rectus, almost concealed by the optic nerve. 11. Parts of the external rectus, showing its two heads of origin. 12. Extremity of the external rectus at its insertion. 13. Inferior rectus. 14. The tunica albuginea, which is formed by the expansion of the tendons of the four recti muscles.

THE NASAL GROUP.—Three muscles: 1. *Pyramidalis nasi*, a slip of fibres extending from the occipito-frontalis downward upon the bridge of the nose; *inserted* into the tendinous expansion of the compressores nasi. 2. *Compressor nasi*, a thin triangular muscle; *arises* from the canine fossa of the superior maxillary bone, and, spreading out on the side of the nose into a tendinous expansion, is continuous across its ridge with its fellow of the opposite side. 3. *Dilator naris*, a thin muscular slip expanded upon the ala of the nostril.

Uses.—The first draws down the inner angle of the eyebrow, and assists the occipito-frontalis; the second *expands* rather

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What motions has the globe of the eye? What muscles constitute the nasal group?

than compresses the nostril; the last dilates the cavity of the nostril.

THE SUPERIOR LABIAL GROUP.—Seven muscles constitute this group: 1. *Orbicularis oris*, a sphincter completely surrounding the mouth, the use of which is to close the lips. 2. *Levator labii superioris alæque nasi;* thin, triangular, *arising* from the nasal process; *inserted*, by two distinct portions, into the ala of the nose and upper lip; its *use* is to raise the upper lip, and expand the opening of the nose. 3. *Levator labii superioris proprius;* thin, quadrilateral, *arising* from the lower border of the orbit; *inserted* into the integument of the upper lip; its *use* is to elevate the upper lip. 4. *Levator anguli oris*, *arising* from the canine fossa of the upper jaw, and, passing outwardly, is *inserted* into the angle of the mouth, which it draws inward and upward. 5. *Zygomaticus major*, and *zygomaticus minor;* two slender fasciculi of fibres, *arising* from the malar bone; *inserted* into the angle of the mouth; they pull the angle upward and outward, as in laughing. 7. *Depressor labii superioris alæque nasi*, an oval slip, *arising* from the incisive fossa; *inserted* into the upper lip, and into the ala and columna of the nose; it lifts the upper lip, with the ala of the nose, and expands the opening of the nares.

THE INFERIOR LABIAL GROUP.—Comprising three muscles: *Depressor labii inferioris; arises* from the side of the symphisis of the lower jaw; *inserted* into the orbicularis muscle and integuments of the lower lip; it draws the under lip directly downward and a little outward. 2. *Depressor anguli oris*, a triangular plane, *arising* from the external oblique side of the lower jaw; *inserted* into the angle of the mouth; it pulls the angle of the mouth either downward and inward, or downward and outward, by the radiation of its fibres, as in the expression of grief. 3. *Levator labii inferioris*, a conical slip, *arising* from the incisive fossa of the lower jaw; *inserted* into the integuments of the chin, which it raises and protrudes.

THE MAXILLARY GROUP.—Five muscles: 1. *Masseter*, short and thick, composed of two planes of fibres, superficial and deep; the *superficial arises* from the tuberosity of the upper

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What muscles constitute the superior labial group? Inferior labial group? Maxillary group?

jaw, the lower edge of the malar bone and zygoma, and is *inserted* into the ramus and angle of the lower jaw; the *deep layer arises* from the back part of the zygoma, and is *inserted* into the upper half of the ramus. 2. *Temporalis*, a broad radiating muscle, occupying a considerable extent of the side of the head, and filling the temporal fossa; *arises* from the temporal ridge, temporal fascia, and temporal fossa, and converging into a strong, narrow tendon, is *inserted* into the coronoid process. 3. *Buccinator; arises* from the alveolar processes of the upper jaw, and from the external oblique line of the lower jaw; inserted into the angle of the mouth, where its converging fibres cross each other. 4. *External pterygoid*, a short, thick muscle, *arising* two-headed from the sphenoid bone; *inserted* into the neck of the lower jaw. 5. *Internal pterygoid*, thick, quadrangular, *arising* from the pterygoid fossa; *inserted* into the ramus and angle of the lower jaw.

Uses.—This group comprises the active agents in mastication. The buccinator circumscribes the cavity of the mouth, and shortens the cavity of the pharynx in deglutition. The masseter, temporal and internal pterygoid, close the jaws, and perform the bruising motions. The two last mentioned, with the external pterygoid, carry the lower jaw forward upon the upper, thus producing the grinding motion. All of these muscles, acting successively, produce a lateral and rotatory movement of the lower jaw

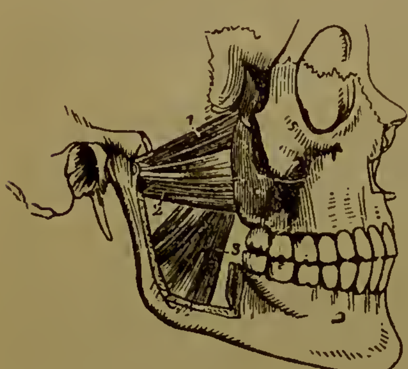

FIG. 93.—PTERYGOID MUSCLES.

The two pterygoid muscles are seen in Fig. 93. The zygomatic arch and most of the ramus have been removed to bring them into view. 1. The sphenoid origin of the external pterygoid. 2. Its pterygoid origin. 3. Internal pterygoid muscles.

THE AURICULAR GROUP.—Three muscles: 1. *Attollens aurem;* 2. *Attrahens aurem;* 3. *Retrahens aurem.* These small muscles of the ear possess ordinarily but little contractility; they raise, extend, and retract the ear in the lower animals, and sometimes, to some extent, in human beings.

What muscles are especially concerned in mastication? What muscles constitute the auricular group?

MUSCLES OF THE NECK.

The muscles of the neck are divided into eight groups, viz.:

THE SUPERFICIAL GROUP.—Two muscles: 1. *Platysma myoides*, *arises* from the integument over the pectoralis major and deltoid muscles; *inserted* into the side of the chin, oblique line of the lower jaw, angle of the mouth, and cellular tissue of the face. It draws the angle of the mouth, depresses the lower jaw, also produces traction on the integuments of the neck. 2. *Sterno-cleido-mastoid* is the large oblique muscle of the neck; *arises* from the sternum and clavicle; *inserted* into the mastoid process and occipital bone. *Uses.*—When both act together the head is bowed forward; either one acting singly draws the head toward the shoulder, and carries the face toward the opposite side. When the clavicular portions act more forcibly than the sternal, they give steadiness to the head, enabling it to support great weights.

THE LARYNGEAL GROUP.—This group is subdivided into *depressors* and *elevators of the os hyoides and larynx.* The *depressors* are four: 1. *Sterno-hyoideus*, a ribbon-like band, *arising* from the back of the upper bone of the sternum and inner extremity of the clavicle; *inserted* into the back of the os hyoides. 2. *Sterno-thyroideus*, a broader band, *arising* from the sternum with the preceding, and from the cartilage of the first rib; *inserted* into the oblique line of the great ala of the thyroid cartilage. 3. *Thyro-hyoideus*, *arises* from the oblique line of the thyroid cartilage; *inserted* into the lower part of the body and great cornua of the hyoid bone. 4. *Omo-hyoideus*, *arises* from the upper border of the scapula and transverse ligament of the supra-scapular notch; *inserted* into the lower border of the body of the hyoid bone.

Uses.—All these muscles pull down the os hyoides and larynx. The first three draw them downward in the middle line; the latter inclines them to one or the other side, according to the position of the head.

The *elevators* are four muscles: 1. *Digastricus*, a two-bellied

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Into how many groups are the muscles of the neck divided? What constitute the laryngeal group?

muscle, *arising* from the inner side of the mastoid process of the temporal bone; *inserted* into the lower jaw near its centre. 2. *Stylo-hyoideus*, a slender muscle, *arising* from the middle of the styloid process; *inserted* into the central part of the body of the os hyoides. 3. *Mylo-hyoideus*, a triangular plane, forming, with its fellow, the floor of the mouth; *arising* from the molar ridge of the lower jaw; *inserted* into the body of the os hyoides, and into the *raphé* of the two muscles. 4. *Genio-hyoideus*, *arising* on the inner side of the centre of the lower jaw; *inserted* into the upper part of the body of the os hyoides.

Uses.—All these muscles raise the os hyoides when the lower jaw is closed, and act upon the lower jaw when the os hyoides is drawn down and fixed by its depressors.

THE LINGUINAL GROUP.—Five muscles: 1. *Genio-hyo-glossus;* this is the proper muscle of the tongue; *arises*, narrow and pointed, from a tubercle on the inner side of the centre of the lower jaw; *inserted* by a fan-shaped attachment into the whole length of the tongue and body of the os hyoides. 2. *Hyo-glossus*, a square plane, *arising* from the great cornua and body of the os hyoides; *inserted* into the side of the tongue. 3. *Lingualis*, consisting of a small bundle, running from the base to the apex of the tongue. 4. *Stylo-glossus*, *arising* from the styloid process and stylo-maxillary ligament; *inserted* into the substance and side of the tongue. 5. *Palato-glossus*, constituting, with its fellow, the constrictor of the isthmus of the fauces; is extended between the soft palate and base of the tongue.

Uses.—The various directions of the fibres of the linguinal muscles give the tongue every conceivable variety of motion. The palato-glossi, assisted by the uvula, close the fauces completely in the act of deglutition.

THE PHARYNGEAL GROUP.—Five muscles: 1. *Constrictor inferior*, *arises* from the upper rings of the trachea, cricoid, and thyroid cartilages; *inserted* into the middle of the pharynx. 2. *Constrictor medius*, *arises* from the great cornu of the os hyoides and stylo-hyoidean ligament, and its fibres, radiating from the origin, are *inserted* into the pharynx and basilar pro-

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What muscles constitute the linguinal group? What muscles form the pharyngeal group?

cess of the occipitis. 3. *Constrictor superior*, *arises* from the molar ridge of the lower jaw, the internal pterygoid plate, and the pterygo-maxillary ligament; *inserted* with the preceding. 4. *Stylo-pharyngeus*, *arising* from the inner side of the base of the styloid process; its fibres spread out beneath the mucous membrane of the pharynx, and are *inserted* into the posterior border of the thyroid cartilage. 5. *Palato-pharyngeus*, *arises* from the soft palate; *inserted* into the inner surface of the pharynx and posterior border of the thyroid cartilage.

Uses.—The constrictors contract upon the food as soon as it passes into the pharynx, and convey it downward to the œsophagus. The stylo-pharyngei draw the pharynx upward and widen it laterally; and the palato-pharyngei draw it upward and assist in closing the opening of the fauces.

PALATAL GROUP.—The muscles of the soft palate are three; their situation is indicated by their names. They are: 1. *Levator palati*, which *raises* the soft palate. 2. *Tensor palati*, which extends the palate laterally, so as to form a septum between the pharynx and posterior nares. 3. *Azygos uvula*, which shortens the uvula.

PRÆVERTEBRAL GROUP.—Five muscles: 1. *Rectus anticus major*, *arises* from the anterior tubercles of the transverse processes of the third, fourth, fifth, and sixth cervical vertebræ; *inserted* into the basilar porcess of the occipitis. 2. *Rectus anticus minor*, *arises* from the side of the atlas; *inserted* with the preceding. 3. *Scalenus anticus*, a triangular muscle, *arising* with the rectus anticus major; *inserted* into the inner border of the first rib. 4. *Scalenus posticus*, *arises* from the posterior tubercles of all the cervical vertebræ, except the first; *inserted* into the first and second ribs by fleshy fibres. 5. *Longus colli*, a long flat muscle, consisting of two portions, the *upper arising* from the anterior tubercle of the atlas, and *inserted* into the transverse processes of the third, fourth, and fifth cervical vertebræ; and the *lower arising* from the bodies of the second and third, and transverse processes of the fourth and fifth, and passing down the neck, to be *inserted* into the

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What muscles constitute the palatal group? What the prævertebral group?

bodies of the three lower cervical and three upper dorsal vertebræ.

Uses.—The rectus major and minor preserve the equilibrium of the head upon the atlas, and when acting with the longus colli, flex and rotate the head and vertebræ of the neck. The scaleni flex the vertebral column, and assist in elevating the ribs in inspiration.

THE LARYNGEAL GROUP will be described with the anatomy of the larynx.

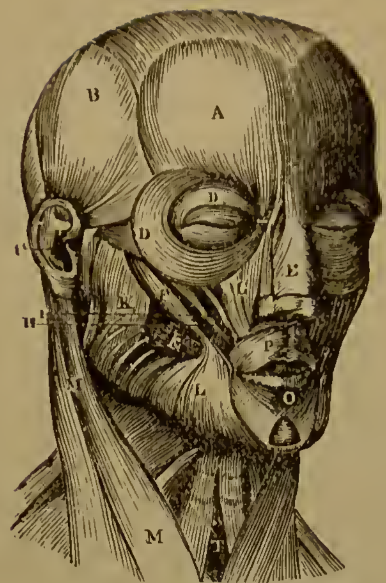

FIG. 94.—MUSCLES OF THE HEAD AND NECK.

FIG. 95.—MUSCLES OF THE HEAD AND NECK.

In Figs. 94 and 95 the most prominent muscles of the head and neck are seen. A. Occipito-frontalis. B. Attollens aurem. C. The concha. D. Orbicularis palpebrarum. E. Compressor naris. F. Zygomaticus major. G. Levator labii superioris alæque nasi. H. Zygomaticus minor. I. Levator anguli oris. K. Masseter. L. Depressor anguli oris. M. Sterno-cleido mastoideus. O. Depressor labii inferioris. P. Orbicularis oris. Q. Temporalis. R. Splenius. S. Trapezius. T. Sterno-hyoideus. *a*. Helix. *b*. Anti-helix. *c*. Concha.

MUSCLES OF THE BACK.

The muscles of the back are divided into six layers.

FIRST LAYER.—Two muscles: 1. *Trapezius; arises* from the upper curved line of the occipitis, ligament of the neck, and spines of the dorsal vertebræ; *inserted* into the spine and acromion of the scapula, and scapular third of the clavicle. 2. *Latissimus dorsi*, covering the whole lower part of the back and loins;

What are the principal muscles of the head and neck? Into how many layers are the muscles of the back divided?

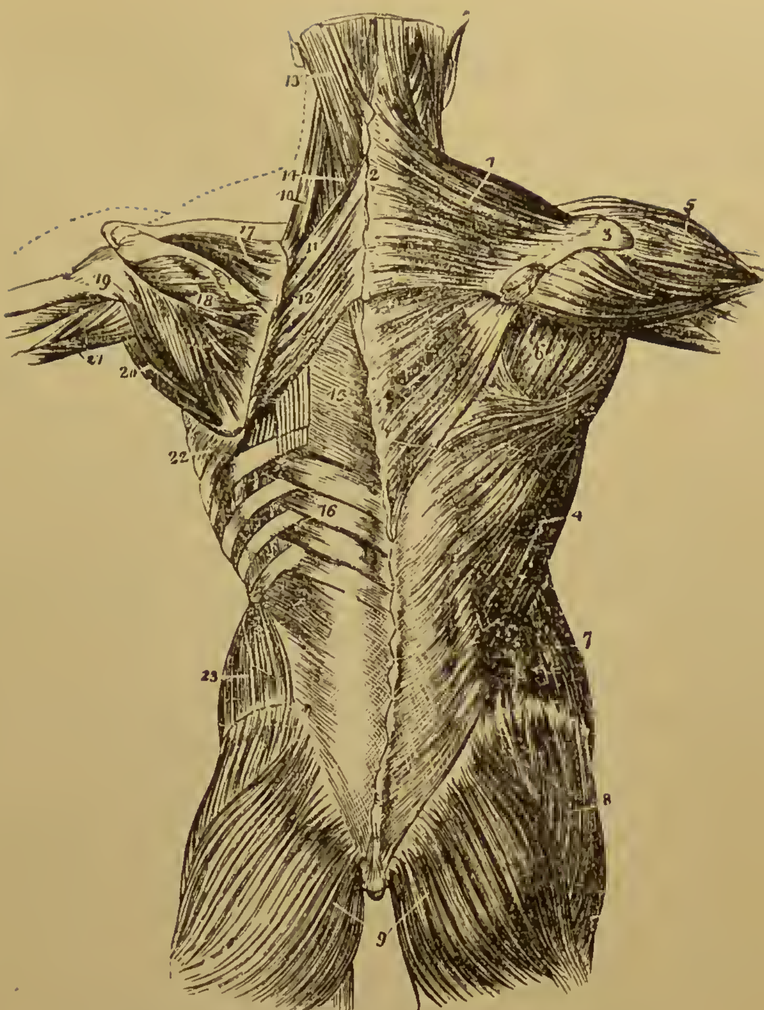

FIG. 96.—EXTERNAL MUSCLES OF THE BACK.

In Fig 96 the first, second, and part of the third layer are seen; the first on the right, and the second on the left side. 1. Trapezius. 2. The tendinous portion which forms, with the corresponding part of the opposite muscle, the tendinous ellipse on the back of the neck. 3. Acromion process and spine of the scapula. 4. Latissimus dorsi. 5. Deltoid. 6. Infra spinatus, teres minor, and teres major, all muscles of the dorsum of the scapula. 7. External oblique. 8. Gluteus medius. 9. Glutei maximi. 10. Levator anguli scapulæ. 11. Rhomboideus minor. 12. Rhomboideus major. 13. Splenius capitis; the complexus is immediately above, and overlaid by it. 14. Splenius colli; partially seen. 15. Vertebral aponeurosis. 16. Serratus posticus inferior. 17. Supra-spinatus. 18. Intra-spinatus. 19. Teres minor. 20. Teres major. 21. Long head of the triceps, passing between the teres minor and major to the upper arm. 22. Serratus magnus, proceeding upward from its origin at the base of the scapula. 23. Internal oblique.

What are the principal external muscles of the back? Where does the long head of the triceps terminate?

arises from the spines of the seven lower dorsal and all the lumbar vertebræ, sacral spines, back part of the crest of the ilium, and three lower ribs; the fibres converge as they ascend, cross the lower angle of the scapula, curve around the lower border of the teres major, and are *inserted* into the bicipital groove of the humerus.

Uses.—The upper fibres of the trapezius draw the shoulder upward and backward, the middle directly backward, and the lower downward and backward. The latissimus dorsi draws the arm backward and downward, and rotates it inward; if the arm be fixed it will draw the spine to that side, and raise the lower rib, thus aiding inspiration; if both arms be fixed, both muscles will draw the whole trunk forward, as in climbing, walking on crutches, etc.

NOTE.—The *ligamentum nuchæ* is a thin cellulo-fibrous layer between the occipital bone and spine of the seventh cervical vertebræ.

SECOND LAYER.—Three muscles: 1. *Levator anguli scapulæ; arises* from the transverse processes of the four cervical vertebræ; *inserted* into the upper angle and posterior border of the scapula. 2. *Rhomboideus minor; arises* from the spines of the two last cervical vertebræ and ligamentum nuchæ; *inserted* into the posterior border of the scapula. 3. *Rhomboideus minor; arises* from the spines of the last cervical and four upper dorsal vertebræ; *inserted* with the preceding.

Uses.—The levator lifts the upper angle of the scapula, and with the rhomboidei carry the shoulder upward and backward.

THIRD LAYER.—These muscles all arise from the spines of the vertebral column, and pass outwardly. There are three of them: 1. *Serratus posticus superior; arises* from the spines of the lower cervical and upper dorsal vertebræ; *inserted* into the upper borders of the upper ribs. 2. *Serratus posticus inferior; arises* from the spines of the two last dorsal and three upper lumbar vertebræ; *inserted* into the lower borders of the four lower ribs. 3. The *splenius muscle*, *arising* from the lower part of the ligamentum nuchæ, and spines of the four lower cervical and six upper dorsal vertebræ; *inserted* by two divisions, the

---

What is the ligamentum nuchæ? What muscles constitute the second layer? Third layer?

first, called *splenius capitis*, into the occipital bone, and the second, called *splenius colli*, into the transverse processes of the upper cervical vertebræ.

Uses.—The serrati are muscles of respiration; their actions antagonize, the posterior drawing the ribs upward to expand the chest, and the inferior drawing down the lower ribs, and diminishing the cavity of the chest, thus rendering the first an *inspiratory*, and the second an *expiratory* muscle. The splenii of one side draw the vertebral column backward and to one side, and rotate the head toward the corresponding shoulder. The splenii of both sides acting together draw the head forward; they antagonize the sterno-mastoid muscles.

Fourth Layer. — Seven muscles: 1. *Sacro-lumbalis; arises* from the back part of the crest of the ilium, posterior surface of the sacrum and lumbar vertebræ; *inserted* by separate tendons into the angles of the six lower ribs. 2. *Longissimus dorsi; arises* with the preceding; *inserted* into all the ribs between their tubercles and angles. 3. *Spinalis dorsi; arises* from the spines of the two upper lumbar and three lower dorsal vertebræ; *inserted* into the spines of all the upper dorsal vertebræ. 4. *Cervicalis ascendens; arises* from the angles of the four upper ribs; *inserted* into the transverse processes of the four lower cervical vertebræ. 5. *Transversalis colli; arises* from the transverse processes of the four upper dorsal vertebræ; *inserted* into the like processes of the five middle cervical. 6. *Trachleo-mastoid; arises* from the transverse processes of the four upper dorsal and five lower cervical vertebræ; *inserted* into the mastoid process. 7. *Complexus*, a large muscle, forming, with the splenius, the great bulk of the back of the neck; *arises* from the transverse processes of the four upper dorsal, and transverse and articular processes of the five lower cervical vertebræ; *inserted* into the occipital bone, near the spine.

Uses.—These muscles hold the vertebral column erect, and assist in steadying the head; the complexus contracts the muscles on the anterior side of the neck; when the muscles of one side act alone, they produce a rotation of the head.

How do the serrati muscles affect respiration? How do the splenii muscles affect the motions of the head?

FIFTH LAYER.—Seven muscles: 1. *Semi-spinalis dorsi; arises* from the transverse processes of the six lower dorsal, and is *inserted* into the spines of the four upper dorsal vertebræ. 2. *Semi-spinalis colli; arises* from the transverse processes of the four upper dorsal, and is *inserted* into the spines of the five upper cervical vertebræ. 3. *Rectus posticus major; arises* from the spines of the axis; *inserted* into the lower curved line of the occipitis. 4. *Rectus posticus minor; arises* from the spinous tubercle of the atlas; *inserted* into the occipitis, below the former. 5. *Rectus lateralis; arises* from the transverse process of the atlas; *inserted* into the occipitis, external to the condyle. 6. *Obliquus inferior; arises* from the spine into of the axis; *inserted* the extremity of the transverse process of the atlas. 7. *Obliquus superior; arises* where the preceding is inserted; *inserted* into the occipitis, between the curved lines.

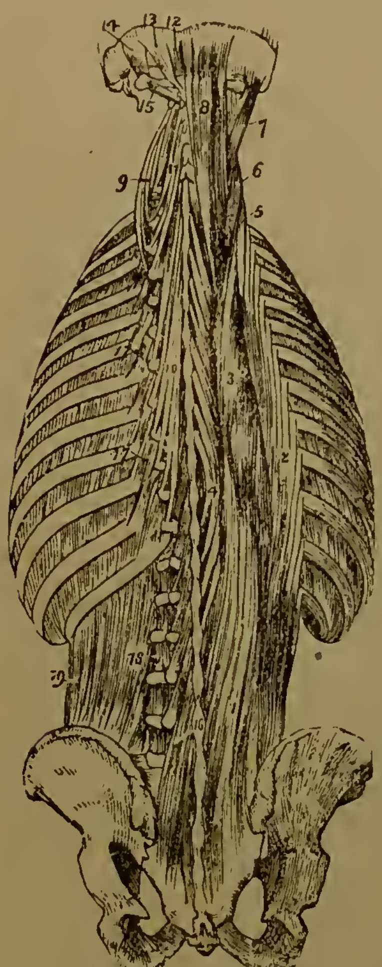

FIG. 97.—INNER MUSCLES OF THE BACK.

Uses.—The semi-spinales contribute to the support of the back in the erect position; the recti produce the antero-posterior, and the obliqui the rotatory movement of the atlas on the axis.

In Fig. 97 are seen the fourth and fifth, and part of the sixth layer. 1. Origin of the sacro-lumbalis and longissimus dorsi. 2. Sacro-lumbalis. 3. Longissimus dorsi. 4. Spinalis dorsi 5. Cervicalis ascendens. 6. Transversalis colli. 7. Trachleo-mastoideus. 8. Complexus. 9. Transversalis colli. 10. Semi-spinalis dorsi. 11. Semi-spinalis colli. 12. Recticus posticus minor. 13. Rectus posticus major. 14. Obliquus superior. 15. Obliquus inferior. 16. Multifidus spinæ. 17. Levatores costarum. 18. Inter-transversales. 19. Quadratus lumborum.

SIXTH LAYER. — Five muscles: 1.

What muscles support the back in the erect position? What muscles rotate the head?

Multifidus spinæ, consisting of bundles of fibres, *arising* from the transverse processes of all the vertebræ from the sacrum to the axis; *inserted* into the spines of the first or second vertebræ above their origin. 2. *Levatores costarum*, consisting of twelve distinct fasciculi on each side, which *arise* from the transverse processes of the dorsal vertebræ, and are *inserted* into the ribs below, between the tubercles and angles. 3. *Supra-spinalis*, composed of fasciculi *arising* from the lower cervical and upper dorsal vertebræ; *inserted* into the spine of the axis. 4. *Inter-spinales*, small slips arranged in pairs, situated between the spines of all the vertebræ. 5. *Inter-transversales*, small quadrilateral slips between the transverse processes of all the vertebræ.

Uses.—The levators raise the posterior parts of the ribs in inspiration; the others are auxiliaries to the larger muscles in supporting the body, and holding the bones in position.

MUSCLES OF THE THORAX.

The principal muscles of the thorax belong also to the upper extremity. Those proper to the thorax are three:

1. *External intercostals.* 2. *Internal intercostals.* 3. *Triangularis sterni.*

The intercostals are eleven internal and eleven external planes of muscular and tendinous fibres, situated obliquely between the adjacent ribs, and filling the intercostal spaces. The fibres of the external are directed obliquely downward and inward, and those of the internal obliquely downward and backward, so that they cross each other.

The *triangularis sterni* is situated within the chest, connecting the side of the sternum and sternal extremities of the costal cartilages with the cartilages of the second, third, fourth, fifth, and sixth ribs. The lower fibres of this muscle are continuous with the diaphragm.

Uses.—The intercostals raise or depressthe ribs, as they act from above or below, being thus both inspiratory and expiratory. The triangularis is a muscle of expiration, by drawing down the costal cartilages.

What are the principal muscles of the thorax? What is the office of the intercostal muscles?

MUSCLES OF THE ABDOMEN.

The muscles of the abdominal region are nine in number:

1. *Obliquus externus;* this is the external, flat, *descending* muscle; its fibres *arise* by fleshy digitations from the eight lower ribs, and spread out to a broad aponeurosis, which is *inserted* into the outer part of the crest of the ilium for one-half its length, into the anterior superior spine of the ilium, spine of the pubis, pectineal line, front of the pubis, and linea alba.

NOTE.—The lower border of the aponeurosis, between the spines of the ilium and pubis, is rounded from being folded inward, and forms *Poupart's ligament.* *Gimbernat's ligament* is that part of the aponeurosis inserted into the pectineal line. The *linea alba* is a white tendinous slip, extending along the middle of the abdomen from the ensiform cartilage to the os pubis. Externally, on each side of it, are two curved lines, extending from the sides of the chest to the pubis, called the *lineæ semi-lunares;* these lines are connected with the linea alba by several cross lines, usually three or four in number, called *lineæ transversæ.* Just above the crest of the pubis is a triangular opening, formed by the separation of the fibres of the aponeurosis, called the *external abdominal ring.* Through this ring passes the spermatic cord in the male, and the round ligament of the uterus in the female; both are invested in their passage by a thin fascia, derived from the edges of the ring, called *inter-columnar*, or *spermatic fascia.* In inguinal hernia, the pouch, in projecting through this opening, receives an additional covering from this spermatic fascia.

2. *Internal oblique;* called the middle *ascending* flat muscle. It *arises* from the outer half of Poupart's ligament, from the middle two-thirds of the crest of the ilium, and from the spines of the lumbar vertebræ; and is *inserted* into the pectineal line, crest of the pubis, linea alba, and five lower ribs.

3. *Cremaster; arises* from the middle of Poupart's ligament; it forms a series of loops upon the spermatic cord, and some

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How many muscles in the abdominal region? What are the principal ones?

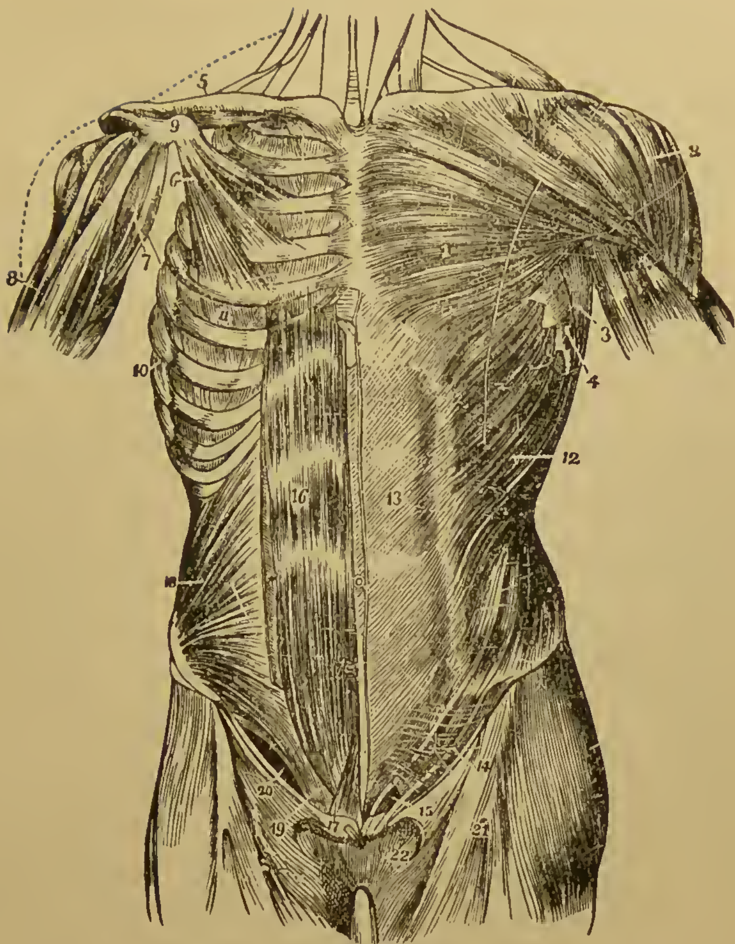

FIG. 98.—MUSCLES OF THE TRUNK.

In Fig. 98 are seen the muscles of the trunk anteriorly. The superficial layer is seen on the left side, and the deeper on the right. 1. Pectoralis major. 2. Deltoid. 3. Anterior border of the latissimus dorsi. 4. Serrations of the serratus magnus. 5. Subclavius of the right side. 6. Pectoralis minor. 7. Coracho-brachialis. 8. Upper part of the biceps, showing its two heads. 9 Coracoid process of the scapula. 10. Serratus magnus of the right side. 11. External intercostal. 12. External oblique. 13. Its aponeurosis; the median line to the right of this number is the linea alba; the flexuous line to the left is the linea semilunaris; the transverse lines above and below the number are the lineæ transversæ. 14. Poupart's ligament. 15. External abdominal ring; the margin above is called the *superior* or *internal* pillar; the margin below the *inferior* or *external* pillar; the curved intercolumnar fibres are seen proceeding upward from Poupart's ligament to strengthen the ring. The numbers 14 and 15 are situated upon the fascialata of the thigh; the opening to the right of 15 is called *saphenous*. 16. Rectus of the right side. 17. Pyramidalis. 18. Internal oblique. 19. The common tendon of the internal oblique and transversalis descending behind Poupart's ligament to the pectineal line. 20. The arch formed between the lower curved border of the internal oblique and Poupart's ligament, beneath which the spermatic cord passes, and hernia occurs.

of its fibres are *inserted* into the tunica vaginalis, the rest into the pectineal line of the pubis.

4. *Transversalis;* this is the internal flat muscle; it *arises* from the outer third of Poupart's ligament, internal lip of the crest of the ilium, spines and transverse processes of the lumbar vertebræ, and from the six lower ribs, indigitating with the diaphragm; *inserted* into the pectineal line, crest of the pubis and linea alba.

5. *Rectus; arises* by a flat tendon from the crest of the pubis; *inserted* into the cartilages of the fifth, sixth, and seventh ribs.

6. *Pyramidalis; arises* from the crest of the pubis in front of the rectus; *inserted* into the linea alba midway between the umbilicus and pubis.

7. *Quadratus lumborum; arises* from the last rib and trans verse processes of the four upper lumbar vertebræ; *inserted* into the crest of the ilium and ilio-lumbar ligament.

8. *Psoas parvus; arises* from the tendinous arches and intervertebral substance of the last dorsal and first lumbar vertebræ; *inserted* by an expanded tendon into the ilio-pectineal line and eminence.

9. *Diaphragm;* this forms a muscular partition between the cavities of the chest and abdomen. In shape it is somewhat conical, and is composed of two portions, called *greater* and *lesser muscles.* The *greater muscle arises* from the ensiform cartilage, inner surfaces of the six inferior ribs, and ligamentum arcuatum externum and internum; from these points its fibres converge to the central tendon, into which they are *inserted.* The *lesser muscle arises* by two tendons from the bodies of the lumbar vertebræ; these tendons form two large fleshy bellies, called *crura,* which ascend and are *inserted* into the central tendon.

NOTE.—The *ligamentum arcuatum externum* is the upper border of the anterior lamella of the aponeurosis of the transversalis. The *ligamentum arcuatum internum,* or *proprium,* is a tendinous arch across the psoas magnus muscle as it emerges from the chest. The *tendinous centre* of the diaphragm is called the *central tendon.* Between the sides of the ensiform cartilage

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What cavities does the diaphragm divide? Of what portions is it composed?

and the cartilages of the adjoining ribs is a triangular space, where the muscular fibres of the diaphragm are wanting; this space is closed by the peritoneum on the abdominal side, and the pleura on the side of the chest. Sometimes, from violent exertion, a portion of the alimentary canal is forced through this space, producing what is called phrenic or diaphragmatic hernia.

Fig. 99 is a side view of the muscles of the trunk. 1. Costal region of the latissimus dorsi. 2. Serratus magnus. 3. Upper part of external oblique. 4. Two external intercostals. 5. Two internal intercostals. 6. Transversalis. 7. Its posterior aponeurosis. 8. Its anterior. 9. Lower part of the left rectus. 10. Right rectus. 11. The arched opening where the spermatic cord passes and hernia takes place. 12. The gluteus maximus, and medius, and tensor vaginæ femoris muscles invested by fascialata.

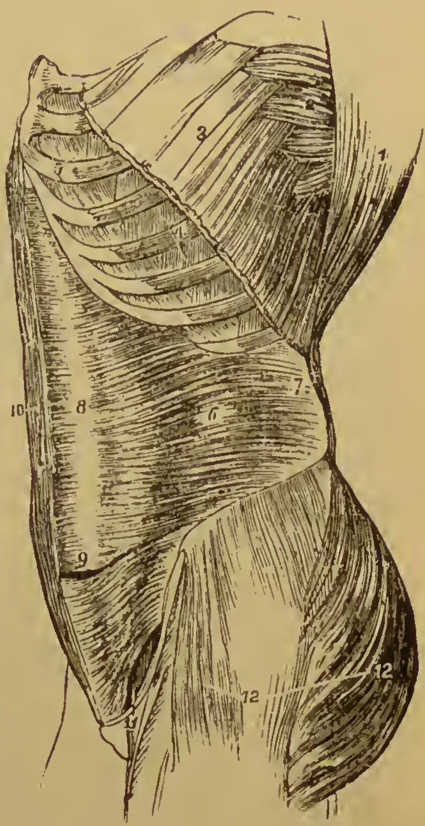

FIG. 99.—MUSCLES OF THE TRUNK LATERALLY.

There are three *openings* in the diaphragm: one in the centre, for the passage of the *inferior vena cava;* an elliptic opening in its muscular portion, formed by the two crura, for the passage of the *œsophagus* and *pneumogastric nerves;* and a third, called the *aortic*, formed by a tendinous arch, which passes from the tendon of one crus to that of the other; beneath this the *aorta*, *thoracic duct*, and *right vena azygos* pass. There are also small openings in the lesser muscle on each side for the great splanchnic nerves.

Uses.—The oblique muscles flex the thorax on the pelvis; either, acting singly, would twist the body to the opposite side. Either transversalis will diminish the size of the abdomen, and both constrict its general cavity. The recti and pyra-

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How many openings are there in the diaphragm? What do they respectively transmit?

midalis together pull the thorax forward; the latter alone are tensors of the linea alba. The quadratus lumborum draws the lower rib downward, and serves to bend the vertebral column to one side. The psoas parvus extends the iliac fascia, and assists in flexing the back. The diaphragm assists the abdominal muscle in expiration.

All the abdominal muscles are respiratory, and constitute the chief forces in the act of expiration. Considering the lungs as a bellows, they constitute the handles. They are aided in this office by the muscles of the loins and back, and to some extent by the upper muscles of the trunk. They compress the cavity of the abdomen in all directions, thus aiding the expulsion of the contents of the stomach, bowels, gall-ducts, bladder, and uterus, and also mucous and irritating substances from the bronchia, windpipe, and nose.

MUSCLES OF THE UPPER EXTREMITIES.

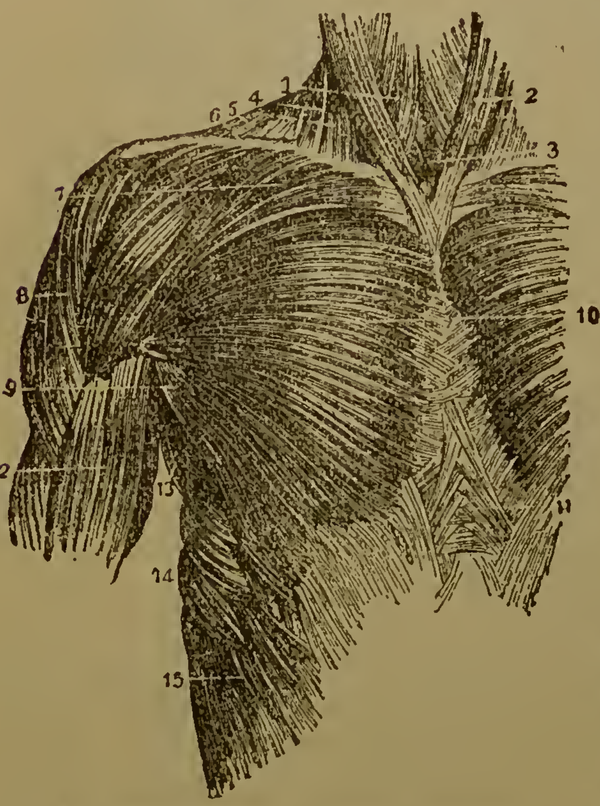

FIG. 100.—MUSCLES OF THORACIC REGION.

1. Sterno-hyoid. 2. Sterno-cleido-mastoid. 3. Sterno-thyroid. 4. Sterno-cleido-mastoid. 5. Edge of the trapezius. 6. Clavicle. 7. Clavicular origin of the pectoralis major. 8. Deltoid. 9. Fold of pectoralis major on the anterior edge of the axilla. 10. Middle of the pectoralis major. 11. Crossing and interlocking of fibres of the external oblique of one side with those of the other. 12. Biceps flexor cubiti. 13. Teres major. 14. Serratus major anticus. 15. Superior heads of external oblique interlocking with serratus major.

THESE are divided by anatomists into several groups, as they pertain to different regions, as *thoracic, scapular, humeral, brachial radial,*

What is the ase of the diaphragm? What are the uses of the abdominal muscles? By what muscles are they aided?

ulnar and *palmar*, meaning *shoulder*, *arm*, *fore-arm*, *waist*, *hand*, and *fingers*.

In Fig. 100 are represented the principal muscles of the thoracic region, which perform the various motions around the shoulder joint, and co-operate in the respiratory function.

The principal muscles of the scapular region are shown in Fig. 101, which is a front view of those of the upper arm.

FIG. 101.—FRONT MUSCLES OF THE UPPER ARM.

1. Coracoid process of the scapula (shoulder blade). 2. Ligament between scapula and clavicle (collar-bone). 3. Coraco-acromial ligament. 4. Subscapularis. 5. Teres major; vessels pass through the triangular space above this muscle. 6. Coraco-brachialis. 7. Biceps. 8. Upper end of the radius. Brachialis anticus. 10. Internal head of the biceps.

FIG. 102.—TRICEPS MUSCLE.

1. Its external head. 2. Its long, or scapular head. 3. Its internal, or short head. 4. Olecranon process of the ulna. 5. Radius. 6. Capsular ligament.

FIG. 101.

FIG. 102.

There are only four muscles of the arm (humeral region), the principal of which are the *biceps* (two-headed), and the *triceps* (three-headed), which perform the most important movements of the arm upon the shoulder joint. The latter muscle is shown in Fig. 102.

The muscles of the brachial region are twenty in number, which are divided by anatomists in four layers, as represented in the following engravings:

What are the principal muscles of the chest? What of the scapular region? Of the arm?

Fig. 103.

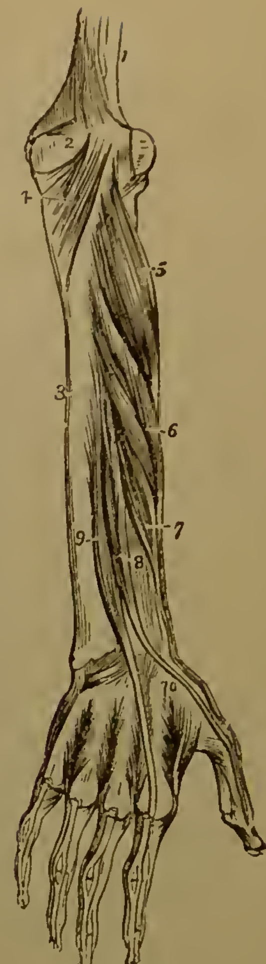

Fig. 104.

Fig. 103.—Superficial Anterior Layer.

. Lower part of the biceps muscle, with its tendon. 2. Part of the brachialis anticus. 3. Part of the triceps. 4. Pronator radii teres. 5. Flexor carpi radialis. 6. Palmaris longus. 7. One of the fasciculi of the flexor sublimis digitorum. 8. Flexor carpi ulnaris. 9. Palmar fascia. 10. Palmaris brevis. 11. Abductor pollicis. 12 One portion of the flexor brevis pollicis. 13. Supinator longus. 14. Extensor ossis metacarpi, and extensor primi internodii pollicis, curving around the lower border of the fore-arm.

Fig. 104.—Deep Anterior Layer.

1. Internal lateral ligament of the elbow joint. 2. Anterior ligament. 3. Orbicular ligament of the head of the radius. 4. Flexor profundus digitorum. 5. Flexor longus pollicis. 6. Pronator quadratus. 7. Adductor pollicis 8. Dorsal interosseous muscle of the middle finger, and palmar interosseous of the ring finger. 9. Dorsal interosseous muscle of the ring finger, and palmar interosseous of the little finger.

What muscles constitute the superficial anterior layer of the fore-arm? What the deep anterior layer?

In Fig. 104 is represented the deep layer of the muscles of the fore-arm.

In Fig. 105 is seen the superficial layer of the muscles of the posterior aspect of the fore-arm.

Synovial Bursæ.—The tendons of the flexor and extensor muscles of the fore-arm are provided with small membranous sacs, filled with a glairy fluid, which serve as cushions for the tendons to play upon.

Fig. 105.

Fig. 106.

Fig. 105. Superficial Layer Posteriorly.

1 Lower part of the biceps. 2. Part of the brachialis anticus. 3. Lower part of the triceps inserted into the olecranon. 4. Supinator longus. 5. Extensor carpi radialis longior. 6. Extensor carpi radialis brevior. 7. Tendons of insertion of these muscles. 8. Extensor digitorum communis. 9. Extensor minimi digiti. 10. Extensor carpi ulnaris. 11. Anconeus. 12. Part of the flexor carpi ulnaris. 13. Extensor ossis metacarpi and extensor primi internodii, lying together. 14. Extensor secundi internodii; its tendon is seen crossing the two tendons of the extensor carpi radialis longior and brevior. 15. Posterior annular ligament. The tendons of the common extensor are seen upon the back of the hand, and their mode of distribution on the dorsum of the fingers.

Fig. 106.—Deep Layer Posteriorly.

1. Lower part of the humerus. 2. Olecranon, process of the elbow joint. 3. Ulna. 4. Anconeus. 5. Supinator brevis. 6. Extensor ossis metacarpi pollicis. 7. Extensor primi internodii pollicis. 8. Extensor secundi internodii pollicis. 9. Extensor indicis. 10 First dorsal interosseous ligament. The other three interossii are seen between the metacarpal bones of their respective fingers.

What muscles constitute the superficial layer posteriorly? What the deep layer posteriorly?

The advantages of this arrangement are sufficiently obvious, considering the exposed situation and rapidity of motion of the tendons, and the feeble protection they receive from the small quantity of flesh and the integument of the wrist. These bursæ are situated where the tendons pass beneath the annular ligament of the wrist, and on the back of the wrist.

In Fig. 106 are seen the muscles which constitute the deep layer of the fore-arm posteriorly.

FIG. 107.—MUSCLES OF THE HAND.

1. Annular ligament. 2, 2. Origin and insertion of the abductor pollicis, the middle portion being removed. 3. Flexor ossis metacarpi. 4. One portion of the flexor brevis pollicis. 5. Its deep portion. 6. Adductor pollicis. 7, 7. Lumbricales, arising from the deep flexor tendons, on which the numbers are placed, the tendons of the flexor sublimis having been removed from the palm. 8. One of the tendons of the deep flexor, passing between the two terminal slips of the tendon of the flexor sublimis, to reach the last phalanx. 9. Tendon of the flexor longus pollicis passing between the two portions of the flexor brevis to the last phalanx. 10. Abductor minimi digiti. 11. Flexor brevis minimi digiti; the edge of the flexor ossis metacarpi is seen projecting beyond the inner border of the flexor brevis. 12. Prominence of the pisiform bone. 13. First dorsal interosseous muscle.

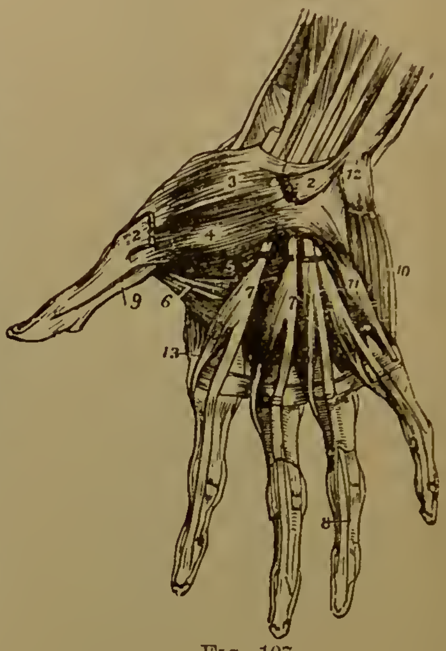

FIG. 107.

The muscles of the hand produce the varied motions of abduction, adduction, and flexion, as their names import.

In addition to the above muscles of the hand, there are four muscles of the ulnar region, and three sets of muscles of the palmar region, all of which are subservient to the muscles of the fingers and thumb.

FIG. 108 shows the principal muscles of the abdomen and of the inguinal canal.

Some of these muscles constitute the walls of the abdominal

What uses of the bursæ about the wrist? What motions do the muscles of the hand produce?

cavity, and hence their health and vigor is essential to a proper action of the abdominal viscera within. They are also intimately connected with the respiratory function, hence their vigorous action is indispensable to free and normal breathing. At the external and internal abdominal rings (6, 7, 10, 15) are

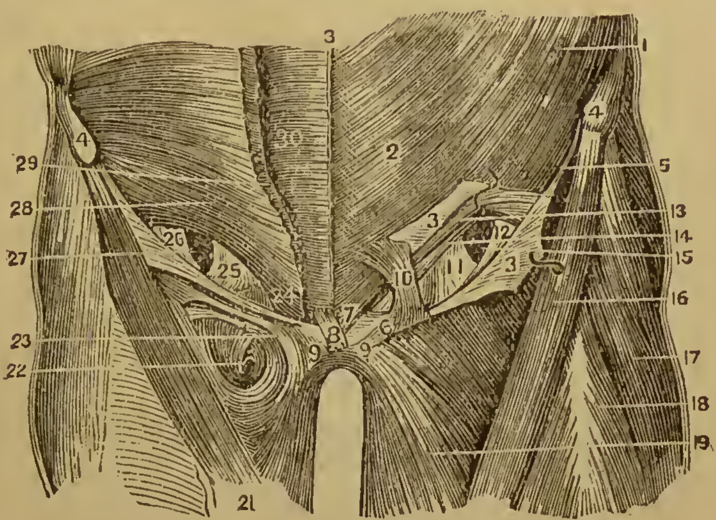

FIG. 108.—ABDOMINAL MUSCLES AND INGUINAL CANAL.

1 External oblique muscle. 2. Its aponeurosis. 3. Its tendon slit up and turned back to show the canal. 4. Anterior superior spinous process. 5. Poupart's ligament. 6. External column of external ring. 7. Internal column of external ring. 8. Intercrossing of the tendons of each side. 9. Body of the pubes. 10. Upper boundary of the external abdominal ring—the line points to the ring. 11, 12. Fascia transversalis. 13. Fibres of internal oblique turned up. 14. Fibres of transversalis muscle. 15. Internal ring enlarged for demonstration. 16. Sartorius. 17. Fascia lata femoris. 18. Rectus femoris. 19. Adductor longus. 21. Fascia lata of the opposite thigh. 22. Point where the saphena vein enters the femoral. 23. Fascia lata as applied to the vessels. 24. Insertion of transversalis muscle. 25, 26. Fascia transversalis. 27. Poupart's ligament turned off from the internal muscles. 28. Transversalis abdominis. 29. Internal oblique. 30. Rectus abdominis.

seen the places where the bowel protrudes in cases of inguinal hernia, suggesting the proper place for applying trusses or pressure.

The principal muscles of the hip are shown in Fig. 109.

The gluteal muscles are abductors of the thigh, when acting from the pelvis as the fixed point; but when the thigh is fixed, they steady and help support the pelvis on the head of the thigh bone, as in standing; they also assist in moving the leg forward in walking. The small gluteal muscle (minimus) rotates the

---

What muscles are intimately associated with the respiratory function? Where do the bowels protrude in inguinal hernia?

limb slightly inward ; the medius and maximus rotate it outward. The other muscles of the gluteal group are termed *external rotators*, their office being to rotate the limb outwardly, by which the knee and foot are everted.

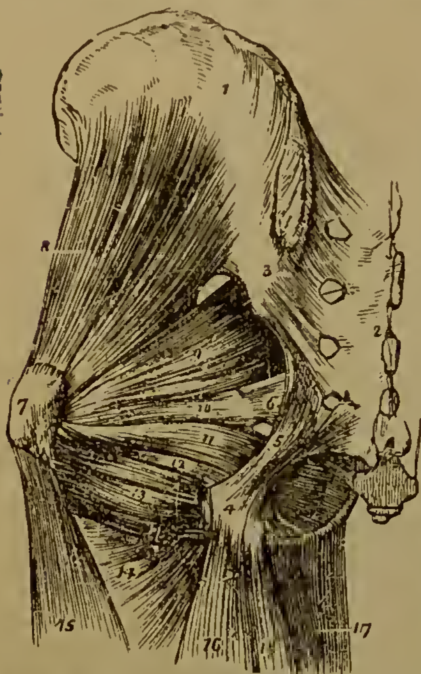

Fig. 109.—Deep Gluteal Muscles.

1. External surface of the ilium. 2. Posterior surface of the sacrum. 3. Posterior sacro-iliac ligaments. 4. Tuberosity of the ischium. 5. Great or posterior sacro-ischiatic ligament. 6. Anterior or lesser sacro-ischiatic ligament. 7. Trochanter major. 8. Gluteus minimus. 9. Pyriformis. 10. Gemellus superior. 11. Obturator internus, passing out of the lesser sacro ischiatic foramen. 12. Gemellus inferior. 13. Quadratus femoris. 14. Adductor magnus, its upper part. 15. Vastus externus. 16. Biceps. 17. Gracilis. 18. Semitendinosus.

Fig. 110 shows the principal muscles of the thigh.

The tensor vaginæ femoris stretches the fascia lata, rendering it tense, and slightly inverting the limb; the sartorius bends the leg upon the thigh, and the thigh upon the pelvis, carrying the leg across that of the opposite side—the tailor's sitting position; when fixed below, it assists the extensors of the leg in supporting the trunk. The four remaining muscles extend the leg upon the thigh. By their attachment to the patella, which acts as a fulcrum, they are advantageously disposed for great power. When their fixed point is from the tibia they steady the thigh upon the leg; and the rectus, by its attachment to the pelvis, serves to balance the trunk upon the lower extremity.

The muscles on the posterior aspect of the thigh are shown in Fig. 111.

The first two are direct flexors, bending the foot upon the leg; acting with the tibialis posticus, they direct the foot inward, and with the peroneus longus and brevis, outward. They help to maintain the flatness of the foot during progression. The

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What motions do the gluteal muscles perform? What are the principal muscles of the thigh?

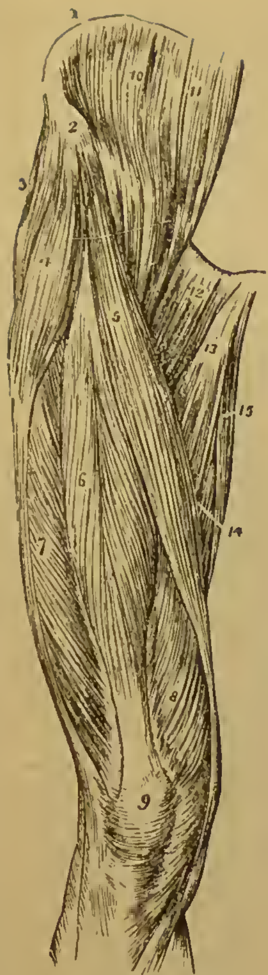

FIG. 110.

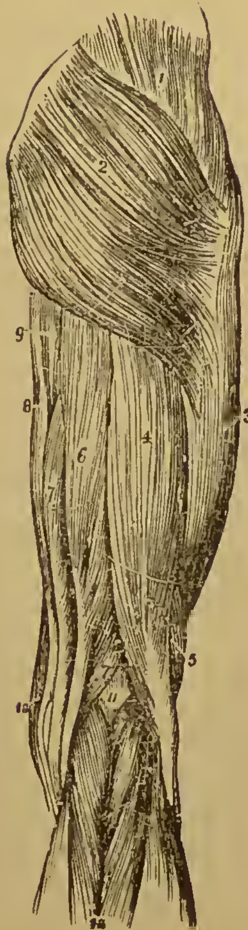

FIG. 111.

FIG. 112.

FIG. 110.—ANTERIOR FEMORAL MUSCLES.

1. Crest of the ilium. 2. Its anterior superior spinous process. 3. Gluteus medius. 4. Tensor vaginæ femoris: its insertion into the fascia lata is seen inferiorly. 5. Sartorius. 6. Rectus. 7. Vastus externus. 8. Vastus internus. 9. Patella. 10. Iliacus internus. 11. Psoas magnus. 12. Pectineus. 13. Adductor longus. 14. Part of the adductor magnus. 15. Gracilis.

FIG. 111.—POSTERIOR FEMORAL MUSCLES.

1. Gluteus medius. 2. Gluteus maximus. 3. Vastus externus covered in by fascia lata. 4. Long head of the biceps. 5. Its short head. 6. Semi-tendinosus. 7. Semi-membranosus. 8. Gracilis. 9. Part of the inner border of the adductor magnus. 10. Edge of the sartorius. 11. The popliteal space. 12. Gastrocnemius; its two heads.

FIG. 112.—SUPERFICIAL TIBIAL MUSCLES.

1. Biceps, forming the outer hamstring. 2. The tendons, the inner hamstring. 3. Popliteal space. 4. Gastrocnemius. 5, 5. Soleus. 6. Tendo Achillis. 7. Posterior tuberosity of the os calcis. 8. Tendons of the peroneus longus and brevis, passing behind the outer ankle. 9. Tendons of the tibialis posticus and flexor longus digitorum, passing into the foot behind the ankle.

What are anterior femoral muscles? Posterior? Superficial tibial muscles?

extensor longus digitorum and extensor proprius pollicis are direct extensors of the toes; they also assist the flexion of the entire foot upon the leg. When acting from below they increase the firmness of the ankle joint.

Fig. 112 is a representation of the principal muscles of the leg.

The muscles of the foot are arranged in layers, and are called *dorsal* or *plantar*, according to their situation above or below. The first layer of the muscles of the sole of the foot is shown in Fig. 113.

FIG. 113.

FIG. 114.

FIG. 113.—FIRST LAYER PLANTAR MUSCLES.

. Os caleis. 2. Posterior part of the plantar fascia divided transversely. 3. Abductor pollicis. 4. Abductor minimi digiti. 5. Flexor brevis digitorum. 6. Tendon of the flexor longus pollicis. 7, 7. Lumbricales.

FIG. 114.—PLANTAR MUSCLES.

1. Divided edge of the plantar fascia. 2. Musculus accessorius. 3. Tendon of the flexor longus digitorum. 4. Tendon of the flexor longus pollicis. 5. Flexor brevis pollicis. 6. Adductor pollicis. 7. Flexor brevis minimi digiti. 8. Transversus pedis. 9. Dorsal and plantar interossei. 10. Convex ridge formed by the tendon of the peroneus longus in its oblique course across the foot.

All the muscles of the foot act upon the toes, the action and nature and situation of each muscle being expressed by its name. The movements of the toes are flexion, extension, adduction,

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What muscles comprise the first plantar layer? Principal plantar muscles?

and abduction. The great toe, like the thumb, is provided with special muscles for independent action. The lumbricales are assistants to the long flexor; and the transversus pedis is placed across the foot for the purpose of drawing the toes together.

The firm articulation of all the metacarpal bones, and the great strength and number of the ligaments and tendons of the leg, feet, and toes, are admirably adapted for combining power

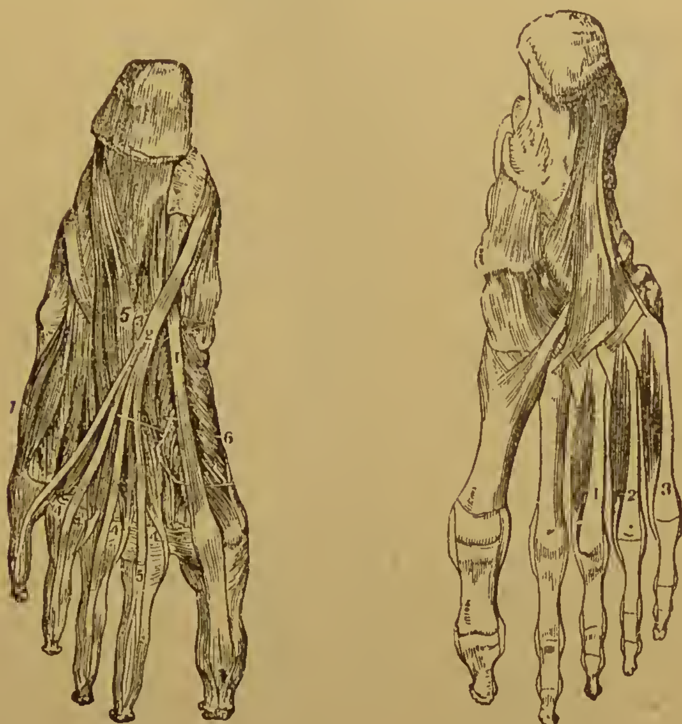

Fig. 115. Fig. 116.

Fig. 115.—Deep Plantar Muscles.

1. Tendon of the flexor longus pollicis. 2. Tendon of the flexor communis digitorum pedis. 3. Flexor accessorius. 4, 4. Lumbricales. 5. Flexor brevis digitorum. 6. Flexor brevis pollicis pedis. 7. Flexor brevis minimi digiti pedis.

Fig. 116.—Plantar Interossei.

1. Abductor tertii. 2. Abductor quarti. 3. Interossei minimi digiti.

of endurance with facility of motion; the toes generally have four flexors, two extensors, four adductors, and four abductors; while the great toe, in addition, has two distinct flexors, two extensors, one adductor, and one abductor.

What are the movements of the toes? What are the deep plantar muscles? Plantar interossei?

CHAPTER VIII.

DIGESTION.

Having treated of the framework of the body (bones and ligaments), and the moving fibres (muscles), in the preceding chapters, we are now prepared to consider the individual functions—the first in order and most important of which is digestion.

Digestion comprises all of the processes of nutrition which are performed in the alimentary canal. It prepares the food-material for absorption into the circulating system, and in its broadest sense embraces the prehension of food, its mastication by the teeth, its admixture with saliva in the mouth, its solution and chymification in the stomach, its chylification and absorption in the intestines, and the expulsion (defecation) of its waste and non-usable matters.

A view of the whole range of the alimentary canal is presented in Fig. 116—a portion of the œsophagus having been removed. The arrows indicate the course of the ingesta.

The abdominal region, which contains the principal digestive organs, is shown in Fig. 117 It is bounded above by the diaphragm, which forms a septum between it and the thoracic cavity (chest), behind by the spinal column, in front and on the sides by the abdominal muscles, and below by the pelvic bones.

PREHENSION.

The manner in which the human being seizes or takes hold of his food, has an important bearing on the question of his "natural dietetic character." Naturalists agree that his teeth, as well as his whole digestive apparatus, belong to the frugivorous organization, and that normally his appropriate food consists of the productions of the earth, fruits and grains especially, whatever may be said in favor of a "mixed diet," because of his acquired tastes and abnormal conditions. And the manner

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What processes does digestion comprise? In what region are the digestive organs? What is prehension?

in which he is organized to seize his food and convey it to the mouth, is another illustration of his frugivorous nature. All

Fig. 116.

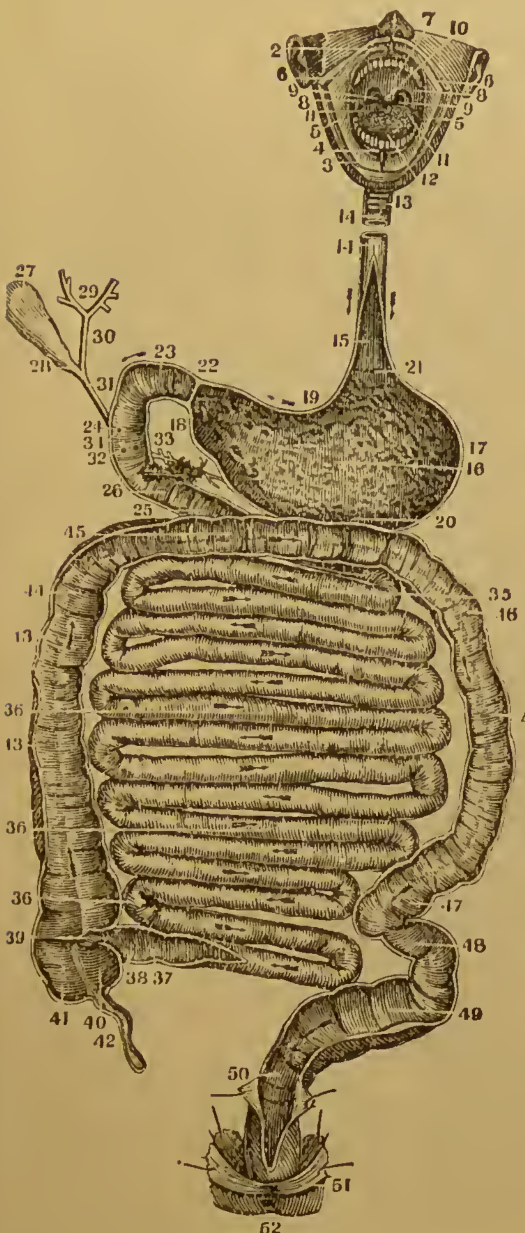

Fig. 116.—The Alimentary Canal.

1. The upper lip, turned off at the mouth. 2. Its frænum. 3. Lower lip, turned down. 4. Its frænum. 5, 5. Inside of the cheeks, covered by the lining membrane of the mouth. 6. Points to the opening of Steno's duct. 7. Roof of the mouth. 8. Lateral half arches. 9. Points to the tonsil. 10. Velum pendulum palati. 11. Surface of the tongue. 12. Pappillæ near its point. 13. A portion of the trachea. 14. Œsophagus. 15 Its internal surface. 16. Inside of the stomach. 17. Its greater extremity or great cul-de-sac. 18. Its lesser extremity or smaller cul-de-sac. 19. Its lesser curvature. 20. Its greater curvature. 21. Cardiac orifice. 22. Pyloric orifice. 23. Upper portion of duodenum. 24, 25. Remainder of the duodenum. 26. Its valvulæ conniventes. 27. Gall bladder. 28. Cystic duct. 29. Division of hepatic ducts in the liver. 30. Hepatic duct. 31. Ductus communis choledocus. 32. Its opening into the duodenum. 33. Pancreatic duct. 34. Its opening to the duodenum. 35. Upper part of the jejunum. 36. Ileum. 37. Some of the valvulæ conniventes. 38. Lower extremity of the ileum. 39. Ileo colic valve. 40, 41. Cœcum. 42. Appendicular vermiformis. 43, 44. Ascending colon. 45. Transverse colon. 46, 47. Descending colon. 48. Sigmoid flexure of the colon. 49. Upper portion of the rectum. 50. Its lower extremity. 51. Portion of the levator ani muscle. 52. Anus.

animals that prey on other animals have claws and tearing teeth, or something analogous, by which to seize its food and

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What evidences that man is naturally frugivorous? How are predaceous animals distinguished?

divide i into fragments for swallowing. The hands of man, so beau fully adapted to plucking the fruits, harvesting the

FIG. 117.—ABDOMINAL CAVITY.

In Fig. 117 the intestines are mostly removed. L, L. The liver, turned up to show its under surface. G. Gall-bladder. P. Pancreas. K, K. Kidneys. S. Spleen. A. Descending aorta. V, V. Ascending vena cava. R. Rectum. B. Bladder.

What do the hands of man indicate in relation to food? In relation to carnivora? In relation to omnivora?

grains, shelling the seeds and nuts, and digging the roots, a e as far removed as possible from the carnivora or even the omni ora.

MASTICATION.

The existence of teeth implies the necessity of masticating the food before it is swallowed. Even the infant masticates, in the physiological sense, the first meal it takes from its mother's breast. The object of mastication is the admixture of each particle of food with a particle of saliva, and this the infant a

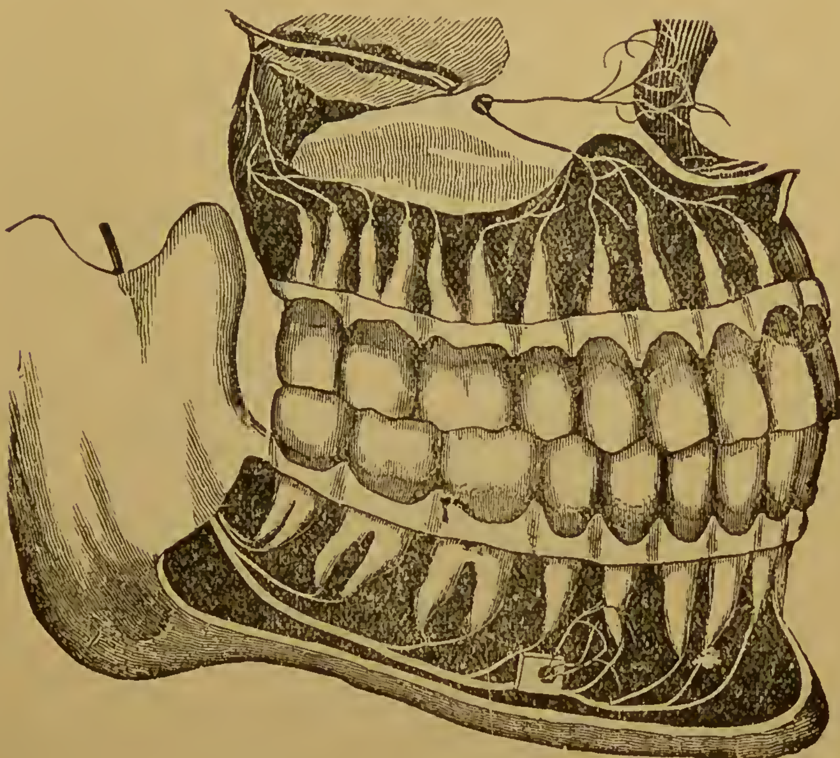

Fig. 118.—The Permanent Teeth.

complishes by taking its milk drop by drop. If the infant swallows its food too rapidly, as often happens when fed from the bottle, it will either vomit it up or suffer of indigestion. And no person, infant or adult, can make the least use of food unless

What is the physiological indication of teeth? How does the infant masticate milk?

it is thoroughly masticated. This is one of the reasons why milk is not a proper article of food for adults, and why any dietary consisting largely of broths, soups, mushes, or slop-food of any kind, is unwholesome.

A complete set of the permanent teeth, with their nervous connections, is shown in Fig. 118.

In this illustration the bony matter is represented as carefully cut away to exhibit the roots of the teeth, and the nerves which connect them with the brain.

Nothing conduces more to the preservation of clean, sound, early teeth than a large proportion of solid food, eaten slowly. Indeed, nothing else can preserve them ; for, like all other organic structures, they perish with disuse. There is no other reason than abuse or disuse why the teeth should decay before the general organization does, than applies equally to the eyes or ears, fingers or toes. Were they as much maltreated as are the teeth, there would be as many eyeless, earless, fingerless, and toeless *young* men and women in the world as there are now toothless ones.

There is an important lesson in the following paragraph, which we copy from "Digestion and Dyspepsia" :

"The Indians are proverbial for their good teeth. We have examined many Indian skulls, and have frequently found the teeth worn down to the gums, with not a speck or decayed spot to be found on them. Besides, we do not find on Indian teeth tartar, or salivary calculus, as is too often the case with civilized men's. There may be many reasons why the teeth of Indians are in better condition than the white man's. The chief one, perhaps, is that they give their teeth ample exercise. If a cow is fed on food that requires no mastication, her teeth become decayed. If she crops the grass with her incisors, and grinds it with her molars, they will last her life-time in good condition; but let her be put into a stable and fed on still-slops, and the teeth at once begin to decay, as also the bony structure in which they stand. The Indian eats parched corn. Having no grist-mill, he grinds his food with his teeth, and the result is,

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Why are so many persons teethless ? How can teeth be best preserved ? For what are Indians proverbial ?

every tooth is exercised. If we eat porridge, broth, stews, and everything else cooked soft, and get no exercise for the teeth, they become to us almost useless; the gums become unhealthy, the teeth decay, and give us a world of trouble. Moreover, the Indian sleeps with his mouth shut, breathes through his nostrils, and does not draw the cold air rapidly over his teeth. This is true of all animals. The canine and feline tribes, that pant when they exercise violently, open their mouths and then breathe through them; but they sleep with their mouths shut. The celebrated Mr. Catlin, who writes on Indian habits, attributes bad teeth to the white man in consequence of sleeping with his mouth open."

FIG. 119.—THE SALIVARY GLANDS.

1. The parotid gland, extending from the zygomatic arch of the cheek-bone to the angle of the jaw below. 2. Duct of the parotid gland. 3. The sub-maxillary gland. 4. Its duct. 5. Sub-lingual gland.

INSALIVATION.

The ample provision which is made for mixing the food with the important solvent furnished by the salivary glands is shown

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What relation has the mouth and nose to normal respiration? How many salivary glands? What are they called?

in Fig. 119, in which all the salivary glands are represented in their natural position.

The situation of the salivary glands—six in number, three on each side—shows their important relation to mastication. They are excited to action by the muscles of the tongue and jaws in the act of mastication.

The saliva is not a material separated from the blood, for it does not exist in the blood, but is formed, or rather *transformed*, from that fluid. All *secretions* are *formative* products, to be *used* in the nutritive processes, in contradistinction to *excretions*, which are the debris or waste material to be expelled. Authors frequently confound these terms, but they are distinct as are supply and waste, or construction and disintegration.

In the order of nature the salivary secretion is sufficient for moistening all the food the system requires ; no animal drinks while eating, and it would be better for digestion if human beings did not. No one who is in good health, and uses only simple and unseasoned food, ever experiences thirst while eating. It is true, however, that all condiments and all high-seasoned viands provoke thirst and necessitate the use of water. Indigestible substances also provoke thirst by occasioning a waste of the fluids of the body.

Fig. 120.—Lobule of Parotid Gland.

In Fig. 120 is represented a single lobule of the parotid gland of an infant. It shows the wonderful provision for insalivating the milk in which the infant feeds. The lobule is injected with mercury and magnified fifty diameters.

DEGLUTITION.

After the food has been properly masticated, it is to be swallowed. The next process, therefore, is *deglutition*. And it is worth a moment's delay to consider the ample, if not wonderful, contrivances for effecting the passage of the food from the mouth to the stomach, without the artificial aid of drink.

What is the saliva? How are secretions distinguished from excretions? What is deglutition?

On each side of the mouth, at the commencement of the *pharynx* (back part of the mouth), is a glandular organ, termed tonsil, whose office is to furnish a lubricating fluid. This is shown in the cut, Fig. 121, 8. In addition to these glands, the whole mucous surface exhales a moistening and lubricating fluid, more refined than any oleaginous matter ever produced

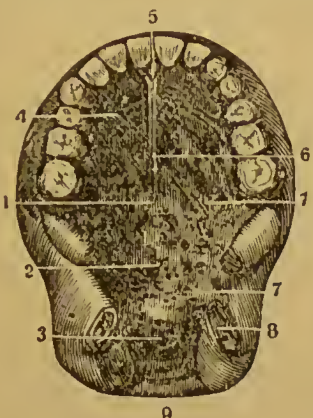

FIG. 121.—A VIEW OF THE ROOF OF THE MOUTH AND OF THE SOFT PALATE.

1. The roof of the mouth, bounded by the superior dental arch. 2. The soft palate. 3. The velum pendulum palati. 4. The ridges seen on the roof of the mouth. 5. The tubercle behind the incisor teeth. 6. The middle line of the hard palate. 7. Orifices of some of the mucous follicles. 8. The tonsil. 9. The pharynx.

by artificial means, that used in sewing machines not excepted. This secretion is formed in tubes, called *mucous follicles*, the orifices of some of which are shown at 7. Persons who use very hot drinks and irritating condiments, or strong alkalies, sometimes have a thickening of the mucous membrane of the œsophagus, which renders deglutition difficult.

A recent work contains a statement of the physiology of the process of Chymification and Chylification so complete and practical that we copy it entire:

CHYMIFICATION.

The second stage of digestion, in the processes of the transformation of the food elements into living structure, is termed *chymification*. This is performed in the stomach. The older physiologists regarded digestion in the stomach as analogous to fermentation ; modern authors are very discordant in their opinions of the nature of the process, some regarding it as mainly mechanical, and others as purely chemical. The simple truth is, it is a *vital* process, as are all other processes pertaining to living organisms.

In the stomach the food is mingled with a solvent, called the

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What is the function of the tonsils? What is the function of the mucous surface of the mouth and throat? What is chymification?

gastric juice, whose wonderful properties have thus far eluded all chemical and microscopical investigations. It is known to be slightly acid, and to have a power of transforming organic elements unlike that of any other known substance. It is said, also, to "digest" inorganic, and even metallic substances, which have been purposely or accidentally swallowed; but this opinion is certainly an error, for oxidation, or decomposition, which is all that can happen to them in the gastric cavity, is a very different process from digestion.

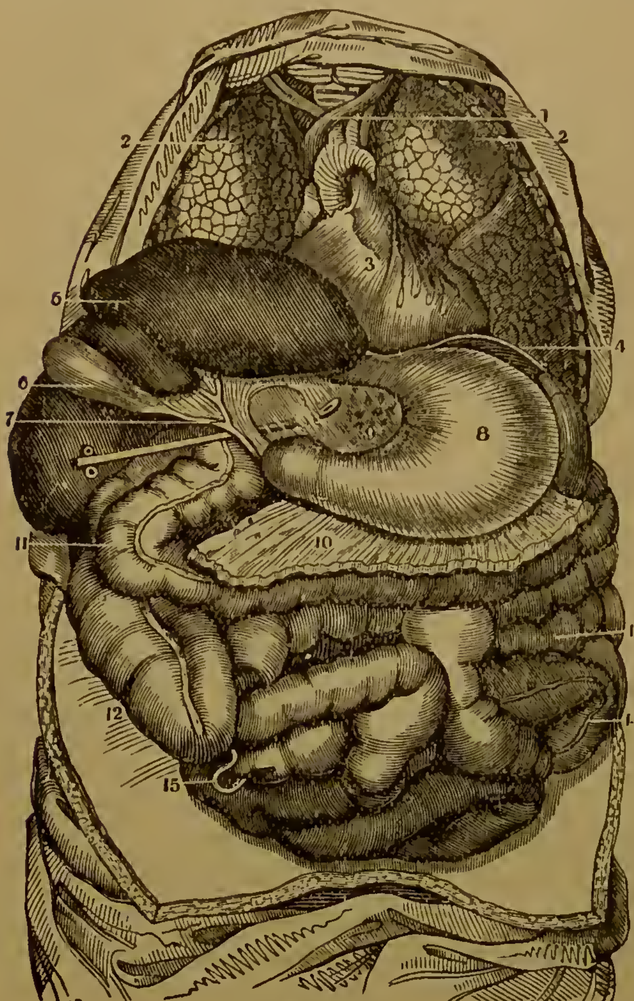

Fig. 122.

1. The great blood-vessels. 2. The lungs of each side. 3. The heart. 4. The diaphragm. 5. Under surface of the liver. 6. The gall-bladder. 7. Union of the cystic and hepatic ducts to form the ductus choledochus, which empties the bile into the duodenum immediately below the pit of the stomach. 8. Anterior face of the stomach. 9. The gastro-hepatic, or lesser omentum. 10. Gastro-colic, or greater omentum, cut off to show the small intestines. 11. Transverse colon, pushed a little downwards. 12. Its ascending portion, also pushed down. 13. Small intestines. 14. The sigmoid flexure of the colon. 15. Appendicula vermiformis.

A general view of the abdominal organs is represented in Fig. 122. The adipose matter in the chest has been removed, as has the *Greater Omentum*, which covers the viscera in front.

The liver also has been turned back to exhibit its under surface and the *Lesser Omentum*.

What is the office of the gastric juice? How does it affect inorganic substances?

It will be noticed that the stomach is nearly semicircular in shape, concave above and toward the liver on the right side, convex toward the spleen on the left side, and that its main bulk is on the left of the median line. The stomach, heart, and spleen are all chiefly on the left side, a provision which seems necessary to counterbalance the largest glandular organ of the body, the liver, which is situated on the right side.

A knowledge of this arrangement of the organs enables us to understand many of the complicated and obscure pathological conditions resulting from congestion and enlargement of the liver. When congested, its very weight causes a painful, dragging sensation in the vicinity of the stomach, and when very much enlarged it causes the body to bend to one side, especially in young persons, often resulting in double curvature of the spine. I have known several children who were badly incurvated, attended in some instances with partial or complete paralysis of one of the lower extremities. And I have known such patients treated for months with tonics, showering, electricity, "movements," and some worse things, without benefit, and without any suspicion on the part of the attending physicians of the real nature of the difficulty. In other cases its pressure against the stomach would cause much distress in that organ, especially after meals. In still other cases its upward pressure against the diaphragm would cause continual difficulty of breathing, occasioning short breath, coughing, and palpitation, whenever the patient would step hurriedly, or walk up-stairs, often resulting in severe asthmatic paroxysms. These patients can never be cured, as the reader will readily understand, until the diseased condition of the liver is properly attended to.

The relation of the stomach to the great blood-vessels below the heart, enables us to explain many strange and often frightful sensations with which all dyspeptics are more or less familiar.

The illustration, Fig. 123, represents the stomach and œsophagus in their natural position, and shows the proximity of the stomach to the descending aorta and other large blood-vessels of the abdominal cavity. The thoracic viscera, nearly all of

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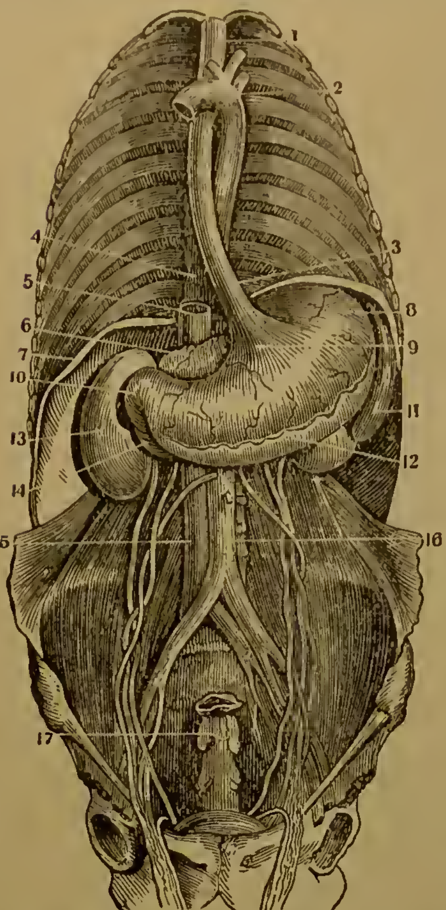
On which side are the stomach, heart, and spleen? What organ opposite?

the diaphragm, and the intestines, have been removed; the peritoneum (lining membrane of the cavity of the abdomen)



1. Upper portion of the œsophagus. 2. Arch of the aorta. 3. Lower portion of the œsophagus. 4. Vertebral column. 5. Vena cava ascendens. 6. Pancreas. 7. The cut edge of the diaphragm. 8. Great cul-de-sac of the stomach. 9. Cardiac orifice of the stomach. 10. Pyloric orifice of the stomach. 11. Spleen. 12. The peritoneal coat of the stomach partially turned off. 13. Right kidney. 14. Lower curvature of the duodenum. 15. Ascending vena cava. 16. Abdominal aorta. 17. A section of the lower bowel (rectum).

Fig. 123.—Stomach and Great Blood-vessels.

has been detached from the kidneys, and the duodenum is left.

One of the most distressing symptoms of many dyspeptics is a hard beating or throbbing behind the stomach. It is generally worse soon after lying down, and the throbbing is sometimes so violent as to jar the whole body and shake the bedstead. Many persons in this condition have apprehended "organic disease of the heart," and not unfrequently their physicians, unable to account for these occasional tumults of the central organ of the circulation on any other hypothesis, have diagnosticated "heart disease."

A reference to the illustration will make the matter plain enough. All dyspeptics have one of four conditions, and many all of them. 1. Constipation. 2. Enlargement of the liver. 3. A contracted and rigid state of the abdominal muscles. 4. Congestion of the adjacent organs—lungs, spleen, kidneys, and pancreas. Any one condition causes obstruction to the free passage of the current of blood down the descending aorta, and

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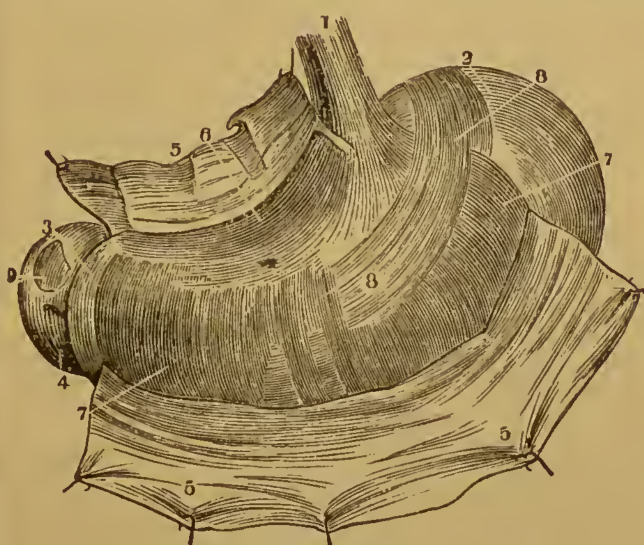
What are the conditions of dyspepsia? Symptoms? How do they affect the heart and blood-vessels?

when all co-operate, the effect is extreme. The swollen organs and unyielding muscles press the stomach directly against the large blood-vessel, so that every contraction of the left ventricle of the heart propels a column of blood through the arteries on which the stomach presses, not only causing the jarring or throbbing sensation, but actually lifting the lower side of the stomach to some extent. The effect is exactly analogous to that of moderate blows or rappings against the under side of the stomach. If the region around the stomach is contracted, as is the case with many "confirmed dyspeptics," or "caved in," as is the case with all women who have laced tightly in early life, this pounding symptom is greatly aggravated. In such cases the patient, on retiring to rest and assuming the horizontal position, will often experience noises in the ears like the



1. Anterior face of the œsophagus. 2. The cul-de-sac, or greater extremity. 3. The lesser or pyloric extremity. 4. The duodenum. 5. A portion of the peritoneal coat, turned back. 6. A portion of the longitudinal fibres of the muscular coat. 7. The circular fibres of the muscular coat. 8. Oblique muscular fibres. 9. Portion of the muscular coat of the duodenum, shown by removing the peritoneal coat.

Fig. 124.—Front View of the Stomach.

"sound of many waters," or the rushing of a cataract. This symptom is also always worse soon after taking a full meal; and if such a person take a "hearty supper," and retire immediately to bed, his sensations will be more forcible than agreeable; and his unquiet slumbers will alternate with paroxysms of incubus, preceded by frightful spectres, fantastic situations, impossible adventures, and all the goblins of air, earth, and sea.

What symptoms result from contracted chest? When are those symptoms worst?

The process of chymification means simply the formation of the food material into a homogenous, pulpy mass For this purpose it is mixed with the gastric juice and compressed and kneaded by the muscles which constitute the middle coat of the stomach. The fibres of this muscular coat are so arranged as to do their work admirably, as is shown in the illustration, Fig. 124, which represents a front view of the stomach, distended with air, the peritoneal coat being turned back.

It will readily be seen that this arrangement of longitudinal, circular, and oblique muscular fibres allows the stomach to compress and knead the ingesta in all possible directions, as the varied motions of the tongue enable it to move the food in the mouth, during mastication, in every direction.

The active principle, or solvent, of the gastric juice, is evidently corpuscular, as is, probably, that of all organic secretions. Something analogous to this has been obtained from the analysis of the gastric juice, and termed pepsine; but pepsine in the living organism, just as nature produces it, and pepsine out of the living organism, as the chemist prepares it, are very different materials, although the latter does produce a solvent effect on alimentary substances. But the idea of introducing pepsine into the materia medica as a substitute for the gastric juice, or as a remedy for indigestion, is as absurd as would be the notion of preparing our food in such a manner as not to require mastication. Indeed, this latter practice is very general, for, do not learned physicians tell us, and eminent physiologists explain to us, that bread, for example, when made light by fermentation, can be more readily permeated by the saliva and gastric juice? Surely they forget, when treating of dietetics, the nature of the physiological function termed mastication.

The pepsine which is employed as a "digester" in medicine, is usually obtained from the stomachs of pigs, by scraping the mucous membrane with a blunt instrument. In order to produce it in large quantities the animals are kept without food until their appetites become keen, and then placed where they can smell the food without getting hold of it. The smell of the savory viands provokes a flow of gastric juice, or of something

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How is food chymified? What is the solvent principle of gastric juice? What is pepsine, natural and artificial?

analogous, which is then obtained pure, as is supposed, by killing the animal. But, as all organic secretions are modified by and partake of the dietetic character of the animal, it seems to me that the omnivorous swine, always filthy and scrofulous in its domesticated condition, is the worst possible source from which to obtain pepsine for the human stomach. The peptic corpuscles of a scrofulous pig may infect the human being with malignant disease, as readily as the vaccine virus from a diseased animal produces the worst forms of confluent small-pox.

The corpuscles of the gastric juice are very tenacious of life, as are all similar secretions. In *rennet*, the dried stomach of the calf, they may retain their organic properties for years. One of the peculiar properties of gastric juice, is that of coagulating milk. Dr. Fordyce long ago ascertained that six grains of the mucous coat of the stomach, infused in water, will produce a liquid that will coagulate one hundred ounces of milk, or 6.857 times its bulk.

It has been ascertained that a single drop of gastric juice contains not less than half a million of corpuscles, and that the quantity necessary for the proper digestion of a single meal may be reckoned in figures at not less than one hundred and thirty thousand millions; a number that need not surprise us when we recollect that modern scientists have estimated the constituent molecules of a drop of water at several billions.

In a prize essay on Cheese-making, by S. R. Arnold, of Lansing, Michigan, published in 1870, the author claims that, in the ordinary process of cheese-making, the corpuscles, or cells, obtained from rennet, are not destroyed in the cheese, but are transferred to the stomachs of those who eat the cheese, and may there assist digestion!

But this is pushing nature quite out of the universe. If cheese, or anything else that contains gastric corpuscles, is necessary or useful in the digestive processes of the human stomach, how are those human beings going to digest their victuals who have not cheese or something similar? And how are the animals that never use any pepsine except the home-made article, to get along? Old cheese is well known to be one of the most indiges-

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What is rennet? Why is pepsine from the pig objectionable? How numerous are gastric corpuscles?

tible articles that was ever swallowed in the name of food, occasioning constipation of the bowels, canker in the mouth, dryness of the mucous surfaces, and deficiency in both the gastric and salivary secretions. Says the old distich :

> "Cheese is a surly elf,
> Digesting all things but itself."

Perhaps Mr. Arnold derived his philosophy from this couplet of the muse. But it is not truth, whatever may be said of the poetry. It is an unnatural and very unwholesome food; indeed, it is not food at all in the proper sense of the word, though containing certain alimentary proximate principles in an altered and degenerated form. Because cheese is a dry food, that is, contains little water, some English medical writers, in view of the scarcity and high prices of flesh-food, consequent on the "rinderpest," "pleuro-pneumonia," and "rot," among so many of the cattle and sheep brought to the London market, have recommended cheese as a substitute. They will find a much better article of diet in that king of the cereals, wheat, provided they know how to cook it hygienically, or in any one of twenty grains, fruits, and roots that could be named.

Another peculiar property of the gastric secretion has been called antiseptic. This term is not strictly correct, for antiseptic applies properly only to dead matter. It is true, however, that partially decayed vegetables and semi-putrescent flesh, lose all offensive odor soon after coming in contact with the gastric juice. But this effect results from the transforming power of the solvent, by which the molecular atoms are rearranged and the fœtid gases decomposed and dissipated. All that an antiseptic can do is to prevent decay by rendering the organic elements fixed and unchangeable, as with salt, vinegar, alcohol, arsenic, etc. This is why all salted aliments are more indigestible and less nutritious than those which are fresh.

In Fig. 126, the entrance to the secreting follicles are shown, in the cells upon the surface of the mucous membrane of the stomach.

The mucous membrane is so completely studded with glands

Is cheese proper food? To what does antiseptic apply? Why are salted foods less digestible than fresh?

for the secretion of the gastric juice that its surface has a velvety or napped appearance, as represented in Fig. 125, which is a section of the coats of the stomach near the pylorus, showing the gastric glands magnified twenty diameters.

The immediate consequences of a deficient supply of gastric juice—a condition that exists with all dyspeptics—are, acidity, flatulence, eructations, water-brash, heart-burn, etc.

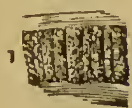

FIG. 125.
GASTRIC GLANDS.

After the food has been duly prepared in the stomach in the manner we have seen, it is passed through the pylorus (lower orifice of the stomach) into the duodenum, the first portion of the small intestines. The pyloric portion of the stomach and the upper portion of the duodenum are liable to become ulcerated, indurated, tuberculated, and even cancerous in persons who have much abused their digestive organs with strong condiments, indigestible aliments, alcoholic liquors or other poisons.

FIG. 126.
SECRETING TUBES.

CHYLIFICATION.

In the duodenum the food, now chyme, is mingled with the secretion from the mucous membrane of the intestine itself, the bile, and the pancreatic juice. Pysiologists do not yet agree as to the precise offices performed in the organic economy by the liver or pancreas. The bile is certainly, in part, and probably wholly, an excrementitious fluid, or excretion, although being of an alkaline nature, it may incidentally mingle with the fatty matters of the food, and by converting them into a saponaceous mass, assist in their passage or absorption. All physicians are familiar with the various phases of disease which result from a deficient excretory action of the liver. Jaundice, rashes, humors, erysipelatous affections, dimness of vision, impaired hearing, and a multitude of cutaneous eruptions are attributable to "biliousness."

What symptoms indicate deficient gastric juice? What is chylification? What results from torpid liver?

The following extract from "The Hydropathic Encyclopedia" may be pertinent in this place:

"The liver forms the bile from the venous blood. The object of the biliary excretion evidently is to eliminate certain impurities from the body in the form of compounds of carbon, hydrogen, and nitrogen, and also to deterge the blood of a portion of any excess of alkali that may be absorbed by the venous extremities.

"Liebig has fabricated a singularly inconsistent hypothesis, which has satisfied himself and all others who are satisfied to ĕcho his arguments without taking the trouble to examine them, that the bile is a nutritive product, and that, consequently, whatever will tend to the formation of bile, or any of the proximate elements usually found in bile, is a useful and nutritive substance. Liebig reasons in this wise: The bile is composed of several certain proximate elements. One of these is called *taurine.* This taurine is the only compound or proximate element found in the bile which contains *nitrogen.* Now *theine* and *caffeine*, the active principles of tea and coffee, are found, on chemical analysis, also to contain a very small quantity of nitrogen; *ergo*, tea and coffee, though injurious excitants to the nerves, may be useful to the liver by furnishing the nitrogenous element of the taurine of the bile. Such reasoning is extremely absurd, and the error is a most palpable one. It consists in mistaking a waste material for an aliment; a depurating process for a nutritive one. As well might one mistake putrid flesh for wholesome food, because it contains carburetted hydrogen, which is also found in the fœces, or excrementitious matters of the bowels."

The pancreatic juice, mingling with the oily matters of the food, or *with* the food (and it should be stated here that oily matters are never digested nor changed in the stomach), reduces them to the condition of an emulsion, which means, dividing the oily particles so minutely that they lose their apparent individuality. In this emulsified condition the fat is capable of being absorbed and carried into the general circu-

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What is the office of the liver? What is the error of Liebig? What is the function of pancreatic juice?

lation, and, finally, expelled through the various emunctories, or deposited in the cells of the areolar tissue.

The spleen, when enlarged and indurated, is what is known in popular parlance as "ague cake." It is common in malarious districts after the intermittent fever has been "broken up" by large doses of quinine or arsenic. When dyspepsia is complicated with this condition, the patient is always despondent and melancholy, unless the organic or vital temperament exists,

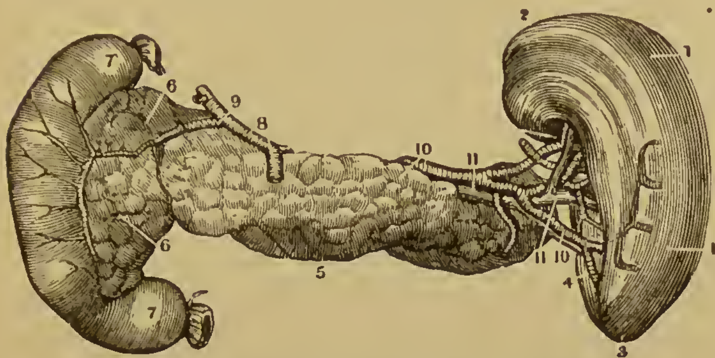

FIG. 127.—PANCREAS, SPLEEN. AND DUODENUM.

*1. The spleen. 2. Its diaphragmatic extremity. 3. Its inferior portion. 4. The fissure for its vessels. 5. The pancreas. 6. Its head, or the lesser pancreas. 7. Duodenum. 8. Coronary arteries of the stomach 9. The hepatic artery. 10. The splenic artery. 11. The splenic vein.

with a very large development of the phrenological organ of hopefulness.

The relation of the pancreas to the spleen on the left side, and the duodenum on the right, is shown in Fig. 127. The cut represents the organs as viewed anteriorly, with their blood-vessels injected.

INTESTINAL DIGESTION.

From the commencement of the small intestines to the termination of the large ones, the mucous lining of the canal secretes a fluid which not only smooths the passage of matters along its surface, but aids in the elaboration of the nutrient elements. In different portions of the alimentary tract there are special glands, follicles, or other secreting structures, aiding in the complex process of converting "pabulum" into living structures. The small intestines are divided by anatomists into

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What is enlargement of the spleen called? What causes produce it? How are symptoms affected by temperament?

the *duodenum*, *jejunum*, and *ileum*, and the large intestines into the *cæcum*, *colon*, and *rectum*. A glance at some of the more prominent of these special appendages to the digestive apparatus will not only show how "fearfully and wonderfully" we are made, but may induce us to have a little more compassion on our own bowels, if we cannot have "bowels of compassion" for others; for it is in the long and tortuous tract of the intestinal canal that the most aggravated miseries of a dyspeptic life are experienced. Choleras, colics, diarrhœas, worms, hemorrhoids, various concretions, and, worst of all, constipation, have their seat in the intestinal tube, in addition to inflammatory affections and structural derangements, which are common to all parts of the system.

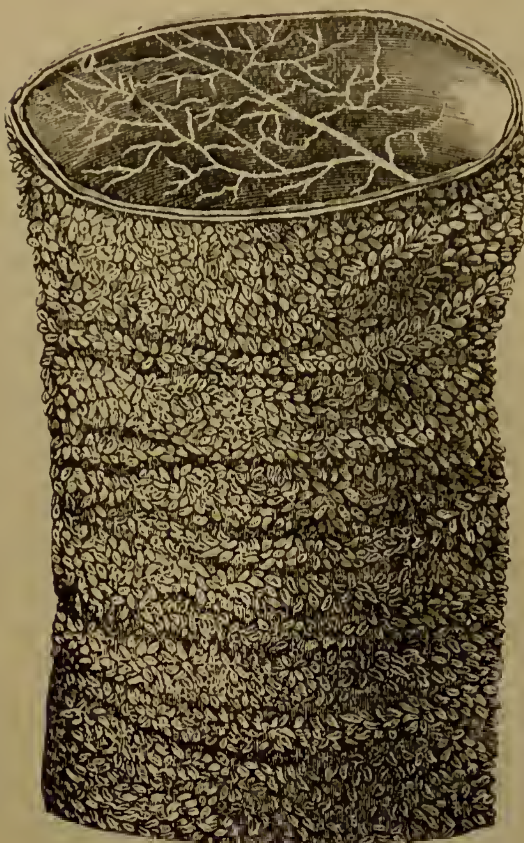

FIG. 128.—SECTION OF THE ILEUM.

In Fig. 128 is seen a section of the ileum, inverted, so as to show the appearance and arrangement of the villi on an extended surface, as well as the follicles of Lieberkuhn. The follicles are represented by the great number of black points between the villi, or projections, and can only be recognized by a close inspection.

A section of the small intestine containing some of Peyer's glands, as shown under the microscope, is represented in Fig. 129. They secrete a milky fluid with numerous corpuscles

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What are the divisions of the large intestines? Of the small intestines? Office of Peyer's glands?

of various sizes, but not so large as those of the blood. The meshes seen in the folds are the ordinary tripe-like folds of the mucous coat.

Several late pathologists have advanced the theory that an inflammation of Peyer's glands in the jejunum and ileum is the essential cause of typhoid, or enteric fever, while an inflammation of Brunner's glands, in the duodenum, is the essential cause of typhus or putrid fever. But these theorists have mistaken effect for cause. In some instances these glands were found inflamed or disorganized after death. In other cases no such appearances were discoverable. If inflammation of these glands were the cause of these fevers, post-mortem examinations should have confirmed it in all cases.

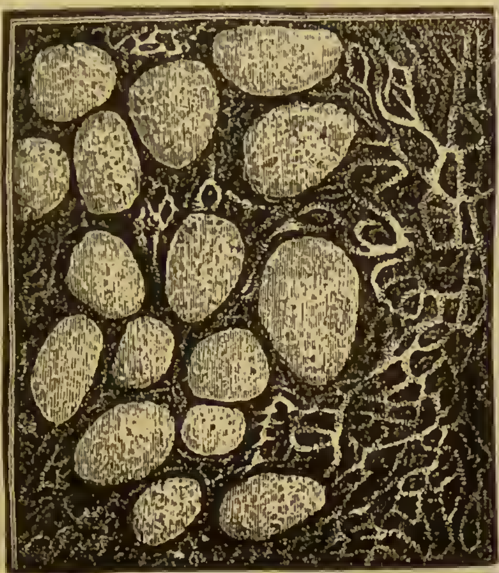

FIG. 129.—PEYER'S GLANDS.

The entire number of follicles in the whole alimentary canal has been reckoned by Dr. Horner ("*Special Anatomy and Histology*"), at "forty-six millions nine hundred thousand and upwards." They constitute the minute anatomy of the mucous coat, and their most prominent phases are represented in the four following illustrations:

Fig. 130 is a view of the follicles of the colon, magnified one hundred and fifteen times. Their aggregate number is estimated at nearly ten millions.

Fig. 131 is a view of the folds and follicles of the stomach, highly magnified. About two hundred and twenty-five are found on every square of an eighth of an inch, which would give a little more than a million and a quarter for the entire stomach.

Of what is the minute anatomy of the mucous coat composed?

In Fig. 132 are seen the follicles and villi of the jejunum, highly magnified. As the villi are erected by the injection, they run into each other and press one upon another, like the convolutions of the cerebrum.

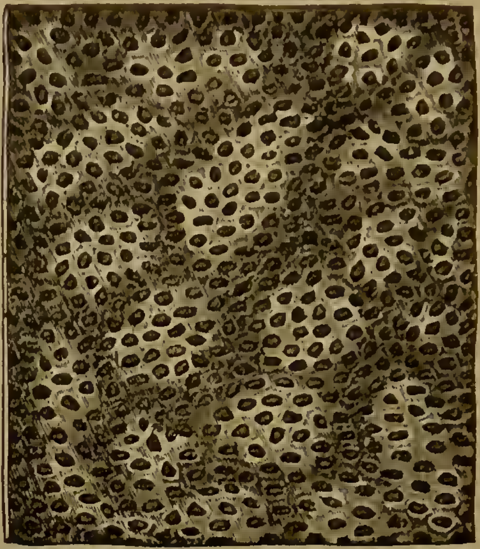

Fig. 130.—Follicles of the Colon.

The follicles and also the villi of the ileum, highly magnified, are represented in Fig. 133. These villi are curved, with their edges bent in, or concave. There is, however, in the whole alimentary canal, almost every conceivable form and shape.

It is in the large intestines, where the fecal matters are liable to accumulate, that the most distressing effects of indigestion are manifested. Admirable as are their structural arrangements and irregularly curviform direction for the performance of their functions under normal conditions, these very circumstances render them liable to become the seat of terrible sufferings when obstructed or diseased. This fact may be inferred from a glance at the illustration, Fig. 134, which is a view of the position and curvatures of the large intestines.

The large intestines differ from the small in being sacculated, an arrangement which favors the retention of the nutrient material which has not yet been taken up by the extremities of the veins and the lacteals, until it can be completely absorbed, and also facilitates the excretion of fecal matters from the blood. But if constipation exist, these sacculations become loaded with hardened fœces, and sometimes with other concretions, rendering the patient as miserable as can well be imagined.

It will be noticed that the contents of the large intestines are carried in a circuitous route, and in one place directly upward

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How do the large intestines differ from the small in structural arrangement?

for ten or twelve inches; thence across the abdominal cavity to the right side, thence downward on the left side to a position

FIG. 131.—FOLLICLES OF THE STOMACH.

below the ileo-cœcal junction; thence through the sigmoid

FIG. 132.—FOLLICLES OF THE JEJUNUM.

flexure (a curvature resembling the letter S), and, finally, downward again in a straight line to the outlet.

What is the direction and route of the contents of the large intestines?

The careless observer might see, in this extraordinary contrivance, nothing but a useless complication that renders the whole organism ever liable to manifold infirmities and premature destruction. But a similar mistake has been made with regard to the convolutions of the brain. There is neither simplicity nor symmetry on the encephalic surface, and its irregular elevations and depressions seem, to the non-philosophical mind, but a promiscuous and useless massing together of brain substance. But the physiologist, and especially the phrenologist, sees the matter with very different eyes. He perceives the use, and then recognizes the beauty of the whole arrangement.

FIG. 133.—FOLLICLES OF THE ILEUM.

He has learned that all of this unevenness of surface unfolds and spreads out, so to speak, the mental organs, and correspondingly augments their power.

The last of the small intestines (ileum) opens into a large sac or pouch, which is the portion of the large intestine termed cœcum. This is very large in some of the herbivorous animals. In the horse it is larger than the stomach. The careful student may inquire, for what purpose is the little, tortuous, worm-like appendage depending from the lower part of the cœcum ? Well,

What is the advantage of the convolutions on the surfaces of organs and structures ?

it has no physiological use whatever, and yet, paradoxical as it may seem, "nothing is made in vain." Like the little tri-jointed bone at the lower extremity of the vertebral column, it seems to point a moral. It is the relic of a lower organization, and is the strongest argument, perhaps, that can be adduced in favor of the doctrine of "Evolution." In some of the lower animals, which subsist on coarse food and herbage, the beaver, for example, the *appendicula vermiformis* constitutes another

FIG. 134.—THE LARGE INTESTINES.

1. The end of the ileum. 2. Appendicula vermiformis. 3. The cœcum, or caput coli. 4. The transverse colon. 5. The descending colon. 6. The sigmoid flexure. 7. Commencement of rectum. 8. The rectum. 9. The anus. The levator-ani muscle is shown on each side.

pouch or stomach, or a prolonged cœcum. As the food becomes more frugivorous and concentrated in the ascending scale, the appendage is not needed, and perishes by non-use. If the human race exists long enough, and continues to develop in its

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What is the *appendicula vermiformis!* What does its presence in man indicate?

cerebro-spinal tissue, the unseemly excrescence will entirely disappear. But I do not wish to be understood as interpreting "Darwinism" so as to make man the "descendant" of the lower organizations. My opinion is that, in the order of progressive development, he has *ascended* above the whole animal kingdom.

Has man "descended" or ascended from the animals?

CHAPTER IX.

ABSORPTION.

ABSORPTION means the conveyance of matters of every kind into the mass of blood. Nutrient materials are carried into the blood, to be distributed to all parts of the body, for purposes of growth and reparation; and noxious matters are carried into the blood to be expelled through the various excretory organs. Absorption is performed by three sets of vessels: lymphatics, lacteals, and veins.

LYMPHATIC ABSORPTION.

The lymphatic system is composed of a net-work of absorbent vessels, originating in all parts of the viscera and areolar structures and tissues, and terminating in the *receptaculum chyli*, the centre of the absorbent system. On their way to the central reservoir they are formed into various convolutions termed glands, whose office is to effect some change or elaboration of the contents of the vessels before they enter the circulation. Fig. 135 presents a general view of the lymphatic system.

The lymphatics are especially the agents of *internal* absorption, while the chyliferous vessels and the extremities of the veins are the agents of external absorption.

The contents of the lymphatic vessels (lymph) consist of a transparent fluid which is slightly alkaline, of a saline taste, and sometimes of a yellowish or madder-red color. As it contains both nutrient material and more or less effete matter, with whatever noxious or foreign materials may be incidentally present, its properties vary in different parts of the system. It contains corpuscles or globules suspended in a watery fluid, and, when out of its vessels and undisturbed, coagulates, as does the blood. In the thoracic duct the lymph mingles with the chyle, and is then poured into the great veins near the heart.

What is understood by absorption? How many kinds of absorbent vessels are there? What is the nature of lymph? What is the center of the absorbent system?

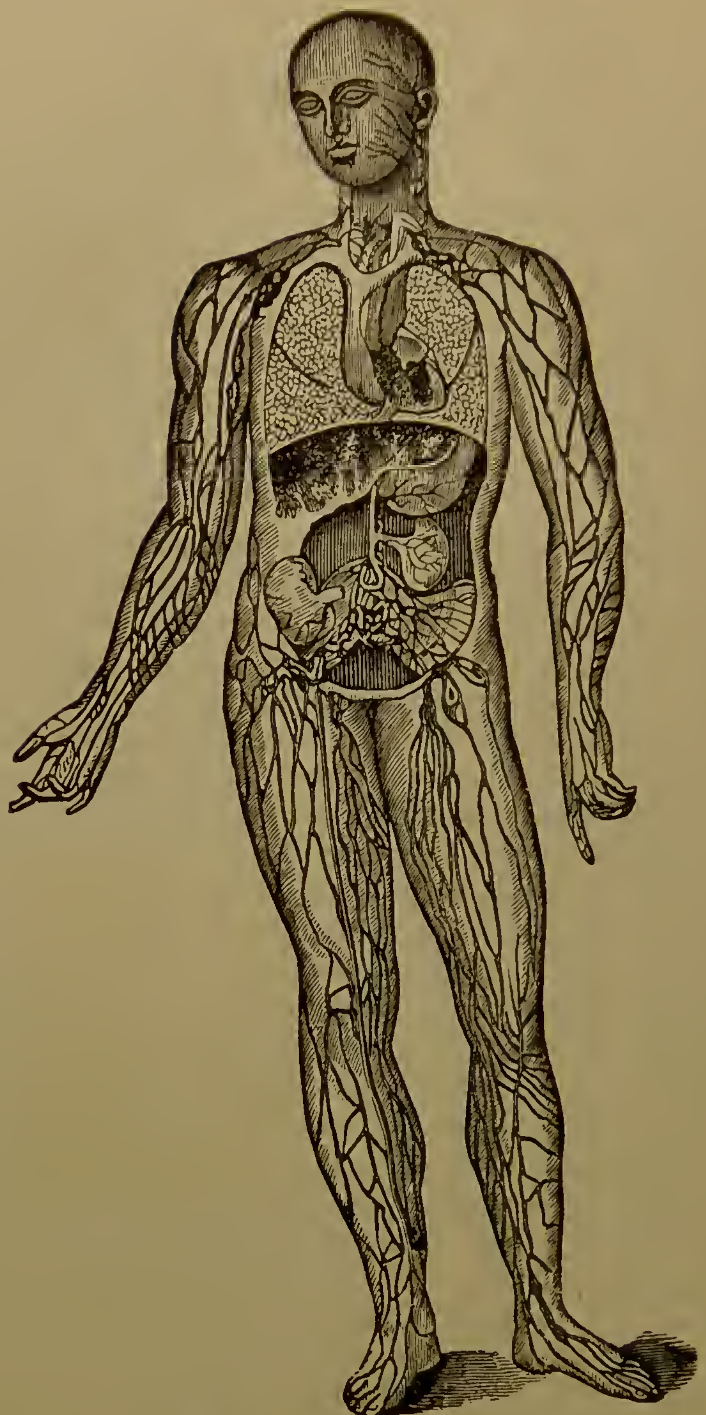

FIG. 135.—LYMPHATIC SYSTEM.

LACTEAL ABSORPTION.

External absorption includes that which takes place from the skin and from the mucous membranes. The lacteal vessels commence by *villi* or *follicles* (crypts, mouths) in the mucous sur-

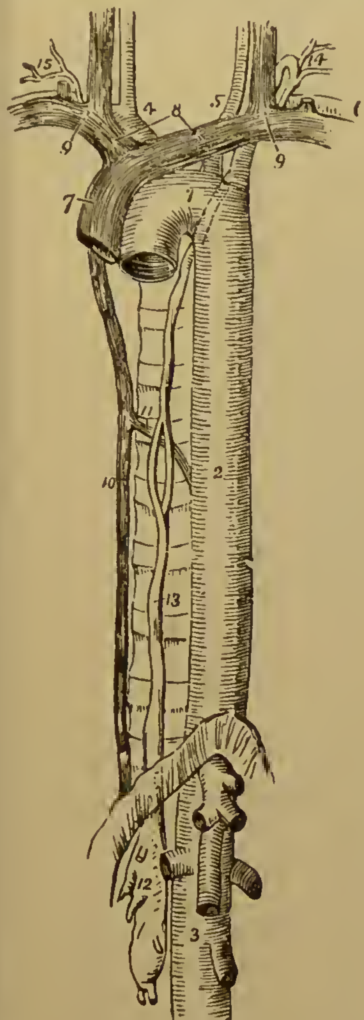

Fig. 136 exhibits the course and termination of the thoracic duct. 1. Arch of the aorta. 2. Thoracic aorta. 3. Abdominal aorta and its branches. 4. Arteria innominata, dividing into right carotid and right subclavian. 5. Left carotid. 6. Left subclavian. 7. Superior cava, formed by the union of 8, the venæ innominatæ, and then by the junction (9) of the internal jugular and subclavian at each side. 10. Greater azygos vein. 11. Termination of the lesser azygos in the greater. 12. Receptaculum chyli; several lymphatic trunks are seen opening into it. 13. Thoracic duct, divided opposite the middle of the dorsal vertebræ into two branches, which soon reunite; the course of the duct behind the arch of the aorta and left subclavian artery is shown by a dotted line. 14. The duct, making its turn at the root of the neck, and receiving several lymphatic trunks before terminating in the venous circulation. 15. Termination of the trunk of the right lymphatic duct.

FIG. 136.—LYMPHATIC CENTRE.

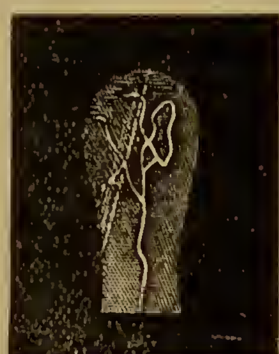

FIG. 137.—LACTEAL ORIGIN.

face of the small intestines, each tube beginning in a single *villus* or closed extremity; the trunk arising from each *villus* is

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What is understood by external absorption? How do the lacteal vessels commence?

formed by the confluence of a number of smaller branches, which anastomose freely with each other in the form of loops, and never commencing in open extremities. This arrangement is represented in Fig. 137.

It seems to be the special office of the lacteal absorbents to take up the oleaginous and viscid matters of the ingesta; hence their contents are of a milky color and consistence. The manner in which lacteal absorption is performed is one of the obscure problems in physiology, as the vessels seem, unlike the lymphatics and venous extremities, to exercise a selective power to some extent—readily taking up some materials and rejecting others. The following diagrams (Figs. 138 and 139) are intended to represent what is known on the subject.

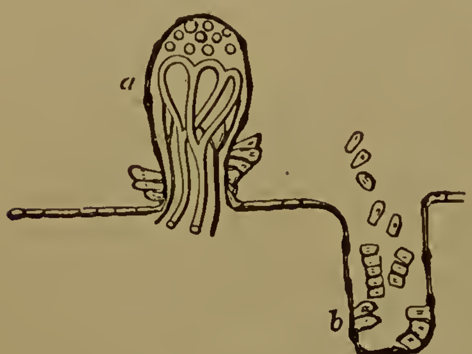

Fig. 138.—Chylification.

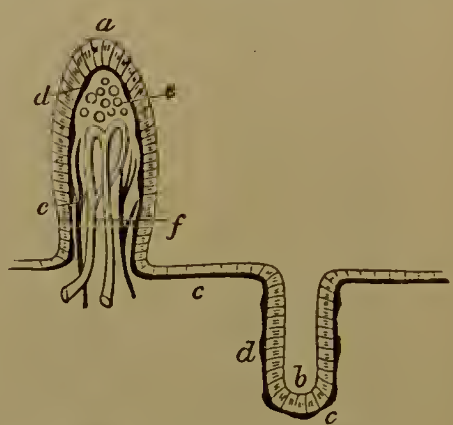

Fig. 139.—Lymphatic Absorption.

Fig. 138 is a diagram of the mucous membrane during digestion and the preparation of chyle. *a.* A villus, turgid and erect; its protective epithelium cast off from its free extremity; its absorbent vessels, lacteals, and blood-vessels turgid. *b.* A follicle discharging its epithelial cells.

Fig. 139 is a representation of the same mucous membrane when chylification is not going on. *a.* Protective epithelium of a villus. *b.* Secreting epithelium of a follicle. *c, c, c.* Primary membrane, with its germinal spots, or nuclei, *d, d. e.* Germs of absorbent vesicles. *f.* Vessels and lacteals of villus.

The loops of the lacteal vessels are embedded in a mass of cells at the extremity of each villus; these cells, when full, yield their contents to the vessels, either by a process of deliquescence or bursting, their place being supplied by fresh cells; and so

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What is the special office of the lacteals? How do lacteals differ from lymphatics and venous extremities?

the process is continued until the nutritive material is exhausted; after which the villi, previously turgid, become flaccid, and the epithelium, which was removed during the process of absorption, is renewed; the lacteal vessels then become the interstitial absorbent vessels of the alimentary canal, and perform the office of ordinary lymphatics.

The milky color of the chyle depends on the presence of minute corpuscles, termed *chyle globules.* The chyle contains fatty, albuminous, fibrinous and saline matters, in varying quantities, according to the food.

Fig. 140 is a beautiful representation of the chyle-carriers.

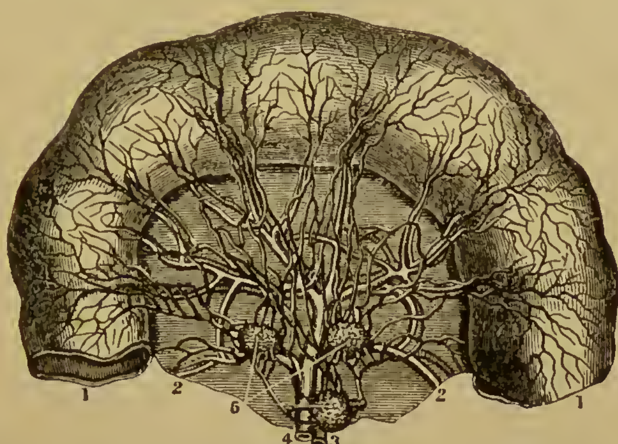

FIG. 140.—LYMPHATICS OF JEJUNUM AND MESENTERY.

Fig. 140. 1. Section of the jejunum. 2. Section of the mesentery. 3. Branch of the superior mesenteric artery. 4. Branch of the superior mesenteric vein. 5. Mesenteric glands receiving the lymphatics of the intestines.

They are represented as injected, as are also the arteries of the jejunum and mesentery.

The structure and arrangement of the mesenteric glands are better shown in Fig. 141, which is a view of the lymphatics as they appeared in a cadaver after death of abdominal dropsy.

VENOUS ABSORPTION.

The extremities of the veins are the principal absorbents for taking up the really effete matters of the system—the debris of

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On what does the milky color of the chyle depend? What is the composition of chyle?

the disorganized structures—as well as the accidental impurities of the body. The lymphatics, however, take up excrementitious matters, as bile, pus, etc.

Most of the nutrient material of the food is carried directly into the circulation by the venous extremities from the stomach and intestines. And as the veins exercise little or no dis-

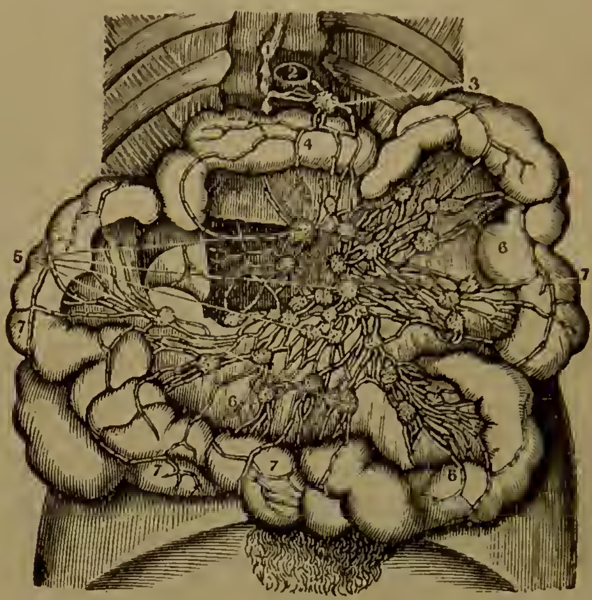

FIG. 141.—MESENTERIC GLANDS.

Fig. 141. 1. Thoracic duct. 2. Section of the aorta. 3. Glands around the aorta which receive the lymphatics from the intestine and give off vessels to the throacic duct. 4. Superficial lymphatics on the intestine. 5, 5. More lymphatic glands receiving vessels from the intestine. 6, 7. Lymphatics from the intestine and mesentery

crimination or "selective affinity," poisons find a ready access to the blood if taken into the stomach.

Absorption from the skin has been termed *accidental*, because the fluids are said to pass by imbibition. The rapidity of this kind of absorption is mainly influenced by the condition of the blood-vessels, being most active when they are most empty. When the epidermis is removed, as by a burn or a blister, the external integument absorbs with great rapidity.

The process of imbibition, however, only applies to the pas-

What is understood by accidental absorption? What circumstances influence accidental absorption?

sage of fluids through the epidermis; that is, between the scales of the scarf-skin or cuticle. In contact with the true skin, matters are absorbed both by the lymphatics and extremities of the veins.

The whole function of absorption is clearly summarized in the "Hydropathic Encyclopedia":

"The venous extremities, acting as absorbent vessels, take up the greater portion of useless, injurious, or worn-out matters; the lymphatic vessels return the unused or surplus recrementitious matters, and also serve as auxiliary vessels, or special provisions to guard against obstructions when the functions of the veins are overtasked or imperfectly performed. The elements of the blood in the capillary system are exhaled through the coats of the vessels, and there undergo certain chemico-vital changes. Such elements as are needed to repair the waste, and build up the structures of the body, are assimilated and become a component part of the body; other elements are separated, and so re-combined as to form the secretions, and waste particles are carried back into the circulation, to be changed or thrown off.

If the processes of alimentation and exhalation overdo those of absorption and depuration, accumulation takes place in the cellular membrane or serous cavities, of adipose or watery matter, and obstruction exists in the form of corpulency or dropsy. Hence obesity is as truly an abnormal or diseased state as dropsy.

What do the venous extremeties absorb? What is the special function of the lymphatic vessels?

CHAPTER X.

RESPIRATION.

THE inspiration of atmospheric air into the lungs, and its expiration therefrom, constitutes the function of respiration. The lungs, which occupy the cavity of the chest on each side of the heart (Fig. 142), are two conical-shaped organs, sep

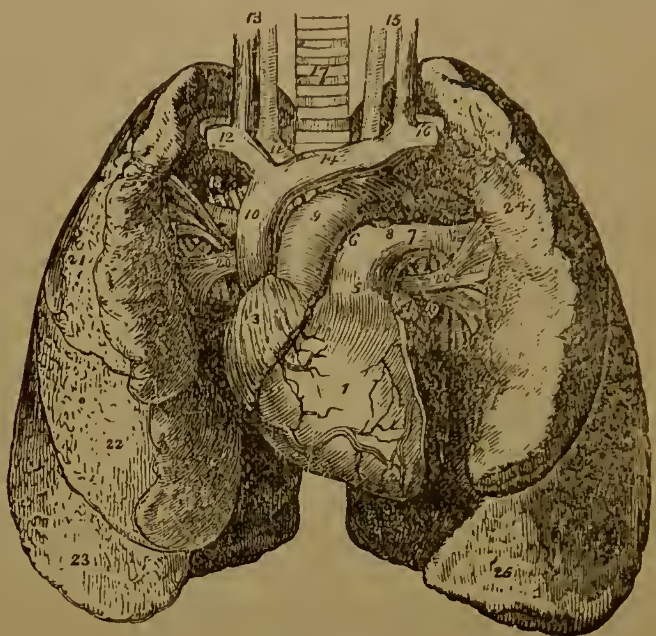

FIG. 142.—HEART AND LUNGS.

Fig. 142 represents the anterior aspect of the anatomy of the heart and lungs. 1. Right ventricle; the vessels to the left of the number are the middle coronary artery and veins. 2. Left ventricle. 3. Right auricle. 4. Left auricle. 5. Pulmonary artery. 6. Right pulmonary artery. 7. Left pulmonary a tery. 8. Remains of the ductus arteriosus. 9. Aortic arch. 10 Superior cava. 11. Arteria innominata; in front of it is the right vena innominata. 12. Right subclavian vein; behind it is its corresponding artery. 13. Right common carotid artery and vein. 14. Left vena innominata. 15. Left carotid artery and vein. 16. Left subclavian artery and vein. 17. Trachea. 18. Right bronchus. 19. Left bronchus. 20. 20 Pulmonary veins; 18, 20, from the root of the right lung; and 7, 19, 20, the root of the left. 21. Upper lobe of right lung. 22. Its middle lobe. 23. Its inferior lobe. 24. Superior lobe of left lung. 25. Its lower lobe.

What is meant by the function of respiration? How are the lungs situated in the chest?

arated from the heart by a membranous partition, the *midiastinum.* They extend upward beyond the level of the first rib, and downward to the convex surface of the diaphragm, on which they rest.

The relation which the lungs occupy anatomically to the stomach, liver, and, indeed, to the whole vital system (Fig. 143), shows the importance to health of a fully-developed and unrestricted play of the breathing apparatus, and the irreparable injury that must necessarily result from all causes that impede its motions.

The structure of the lungs is composed of ramifications of the bronchial tubes, terminating in intercellular passages and air-cells, and the ramifications of the pulmonary artery and vein, bronchial arteries and veins, lymphatics and nerves, the whole connected together by areolar tissue.

The number of respirations in a healthy adult average fifteen to eighteen per minute, being about one-fourth as rapid as the pulsations of the heart. About one pint of air enters the lungs at each inspiration. Pure atmospheric air consists of about twenty-three parts of oxygen *mixed,* but not chemically, united with seventy-seven parts of nitrogen. The air we ordinarily breathe contains about one-fourth of one per cent. of carbonic acid gas, and a small proportion of ammonia, averaging about one-fourth of a grain to about twenty thousand cubic inches of air. Other gaseous matters occasionally exist as accidental impurities.

Respiration is the special process by which the blood is freed of its effete carbon—purified or decarbonized; hence, when the breathing is arrested for a moment, there is a livid discoloration of the surface and a sense of suffocation, due to the accumulated carbon. Consumptives, whose lungs are obstructed with tubercles, suffer more or less of these symptoms; and young ladies who restrict the motions of the chest by tight-lacing are destroying themselves suicidally.

The air expired from the lungs contains sixteen parts in one hundred less of oxygen than the air inspired, while it has

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What is the structure of the lungs? Of what is atmospheric air composed? How does respiration affect the blood?

gained about fourteen per cent. of carbon; the nitrogen is sometimes increased and sometimes diminished by respiration, while at other times its quantity remains unchanged.

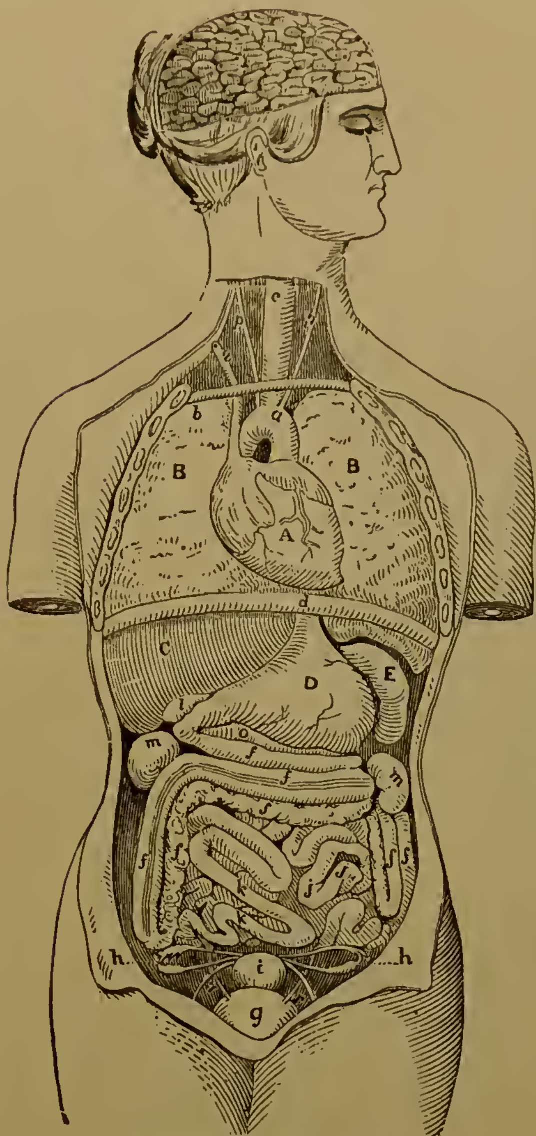

Fig. 143.—Vital System.

It is not known that oxygen is used in any manner in the organic economy, except as a disintegrating agent; but there are reasons for presuming that it may also serve as a carrier for vitalizing elements more subtle and refined than our senses, aided by microscopes, can take cognizance of, except in their effects—just as water is a carrier of blood-cupuscles and the nutrient elements of food.

A. Heart. B, B. Lungs. C. Liver. D. Stomach. E. Spleen. *m*, *m*. Kidneys. *g*. Bladder. *d*. is the diaphragm which forms the partition between the thorax and abdomen. Under the latter is the cardiac orifice of the stomach, and at the right extremity, or pit of the stomach, is the pyloric orifice.

Aquatic animals breathe by means of *gills*, which are membranes prolonged externally into tufts or fringes, through which the aeration of the blood is efected. Insects have a series of tubes ramifying through the whole body, and carrying air to the blood of every part.

In the human lung the sides or walls of the air-cells are constituted of a thin transparent membrane, and the capillary

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What relations have carbon, nitrogen, and oxygen to respiration? How do aquatic animals breathe?

vessels are situated between the walls of two adjacent cells, so as to be exposed to the action of the air on both sides. The number of the air-cells of the lungs have been estimated at six hundred millions.

Fig. 144 represents the bronchial tube, and its division into air-cells, greatly magnified.

The capacity of the lungs varies greatly in different individuals. M. Bourgery concludes from his inquiries that the de-

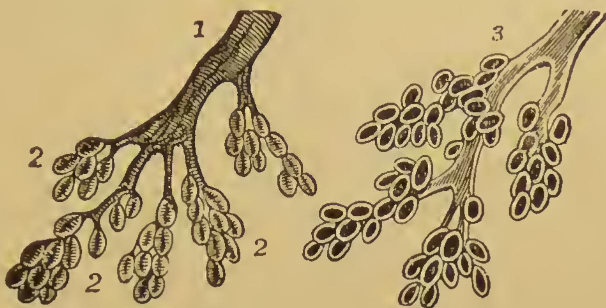

FIG. 144.—BRONCHIAL TUBE AIR VESICLES.

1. A bronchial tube. 2, 2, 2, Air-cells or vesicles. 3. 4. A bronchial tube and vesicles laid open.

velopment of the air cells continues up to the age of thirty, at which time the respiratory capacity is greatest. According to the experiments of Mr. Coathupe, about 266⅛ cubic feet of air pass through the lungs of a middle-sized man in twenty-four hours. At the average number of sixteen inspirations per minute, the amount of air received at each inspiration would be twenty cubic inches. Mr. Hutchinson judges the capacity of the lungs by "the quantity of air which an individual can force out of the chest by the greatest voluntary expiration after the greatest voluntary inspiration." Dr. Southwood Smith, from a series of experiments, estimates the volume of air received at an ordinary inspiration at one pint, the volume ordinarily present in the lungs at about twelve pints, and the volume expelled at an ordinary expiration at a little less than a pint. He also concludes that in the mutual action which takes place between the air and blood, the air loses thirty-seven ounces of oxygen and the blood fourteen ounces of carbon every

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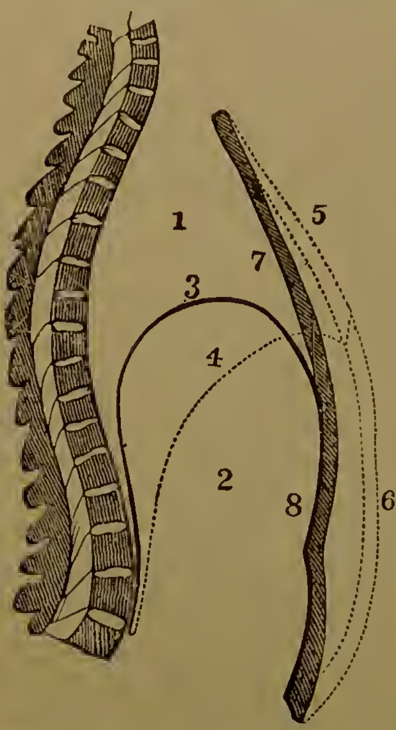
How are human air-cells constituted? How much air is received at each inspiration?

twenty-four hours. The lightness of the lungs depends on the residuary air they contain, and when the lungs have been once inflated by a full inspiration, no force or mechanical power can again dislodge the air sufficiently to make them sink in water. It is this residuary air which supports life a few minutes in cases of suffocation, immersion, etc.

The movements of the respiratory apparatus are partly voluntary, for the purposes of being subservient to voice and speech, and partly involuntary, for the purposes of aeration. The lungs themselves are entirely passive in respiration. When the walls of the chest are drawn asunder, and the thorax dilated, the external air rushes in to the air cells, distending them in proportion to the dilatation of the thorax, and keeping the surface of the lungs all the while accurately in contact with the walls of the chest in all their movements. But if air be admitted into the cavity of the pleura outside of the lungs, as by a penetrating wound of the thorax, the lungs cannot be fully distended by inspiration, but will remain partially collapsed, although the thorax expands, because the pressure of air from without the air cells balances that within.



145.—ACTION OF THE DIAPHRAGM

Fig. 145 is a side view of the chest and abdomen in respiration. 1. Cavity of the chest. 2. Cavity of the abdomen. 3. Line of direction for the diaphragm when relaxed in expiration. 4. Line of direction when contracted in inspiration. 5, 6. Position of the front walls of the chest and abdomen in inspiration. 7, 8. Their position in expiration.

The diaphragm, by extending the ribs, and pressing down the abdominal viscera, is the principal agent in inspiration; in a deep inspiration the intercostal muscles assist in the expansion of the chest by spreading the ribs, aided also, to some extent, by

On what does the lightness of the lungs depend? What are the movements of the respiratory apparatus?

the muscles of the thorax generally. Expiration is mainly accomplished by the abdominal muscles, whose contraction draws down the ribs and compresses the viscera up against the relaxed diaphragm, thus diminishing the cavity of the thorax from below.

The connection of the respiratory function with sensibility, or the sense of feeling, is an interesting and as yet almost unoccupied field of inquiry. According to the experience of drowning persons—those who have remained from one to several minutes under water without breathing, and afterward been resuscitated—there is no pain after the complete suspension of respiration. Although intellectual consciousness remains, and mental conceptions are greatly exalted and intensified, all sensations of mere bodily suffering are absent. The anesthetic effects of ether and chloroform appear to bear a close relation to the extent to which the breathing is suspended. A complete unconsciousness to pain is attended with an extremely feeble and sometimes almost imperceptible respiration.

How is expiration accomplished? What is the relation of respiration to esnsibility?

CHAPTER XI.

CIRCULATION.

The circulating system comprises the heart, arteries, veins, and capillary vessels. The *heart* is the central organ of the circulation; it is not essential to the circulation, for some of the lower animals do not have it. Its office is doubtless to regulate the distribution of blood. The *arteries* convey the pure blood to all parts of the body from the heart. The veins return the impure blood from all parts of the body to the heart. The capillaries are fine, hair-like tubes, intermediate between the arteries and veins, and contain the common or mixed blood of the system.

The course of the circulation is as follows: commencing at the heart, as the central point of the circulating system, the blood is received from all parts of the *venous* system into the *right auricle* of the heart; the auricle, contracting, forces the blood into the *right ventricle;* the ventricle, contracting, sends the blood into the *pulmonary artery;* this artery divides into branches, which are ramified through the substance of the lungs, thus bringing the blood in contact with the millions of air-cells, where aeration takes place, changing the blood from venous to arterial; the blood thus purified is returned through the *pulmonary veins* to the *left auricle* of the heart; from the left auricle it is passed into the *left ventricle;* thence into the *aorta*, which, dividing and sub-dividing into smaller arteries, conveys the pure or arterial blood to all parts of the body.

The general structure of the heart is an arrangement of strong muscular fibres disposed in layers, so as to form fibrous bands and rings, thus affording the greatest possible amount of strength for bulk.

The blood, when removed from its circulating channels, soon separates into a thick portion called *crassamentum*, or *clot*, and

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What does the circulating system comprise? What is the course of the circulation?

a *serous* or *watery portion*, the former consisting of its condensed or coagulated solid constituents, and the latter composed principally of water and various saline substances in solution.

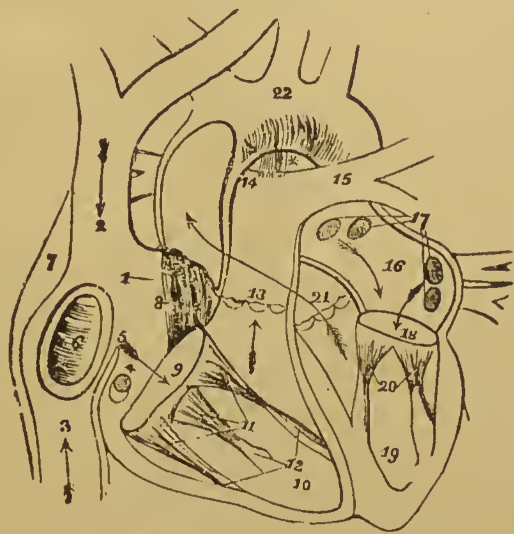

FIG. 146.—ANATOMY OF THE HEART.

Fig. 146 is a general view of the internal structure of the heart. 1. Right auricle. 2. Entrance of the superior cava. 3. Entrance of the inferior cava. 4 Opening of the coronary vein, half-closed by the valve. 5. Eustachian valve. 6. Fossa ovalis, surronnded by the annulus ovalis. 7. Tuberculum Loweri. 8. Musculi pectinati in the appendix auriculæ. 9. Auriculo ventricular opening. 10. Cavity of right ventricle. 11. Tricuspid valve, attached by the chordæ tendinæ to the carneæ columnæ (12). 13. The pulmonary artery, guarded at its commencement by three semilunar valves. 14. Right pulmonary artery, passing beneath the arch and behind the ascending aorta. 15 Left pulmonary artery, crossing in front of the descending aorta. * Remains of the ductus anteriosus, acting as a ligament between the pulmonary artery and arch of the aorta. The arrows mark the course of the venous blood through the right side of the heart. 16. Left auricle. 17. Openings of the fourth pulmonary veins. 18. Auriculo-ventricular opening. 19. Left ventricle. 20. Mitral valve, attached by its chordæ tendinæ to two large columnæ carneæ, which project from the walls of the ventricle. 21. Commencement and course of the ascending aorta behind the pulmonary artery, marked by an arrow; the entrance of the vessels is guarded by three semi-lunar valves. 22. Arch of the aorta. The comparative thickness of the two ventricles is shown in the diagram. The course of the blood through the left side of the heart is denoted by arrows.

The whole quantity of blood is usually about one-fifth of the entire weight of the body. The whole quantity of blood passes through the heart every five minutes or less.

What is the usual quantity of blood? How often does it all pass through the heart?

The *frequency* of the heart's contractions, commonly called the beats of the pulse, gradually diminish from the commencement to the end of life. The average frequency immediately after birth is 120 to 130; in middle life, 65 to 75, and in old age, 65 to 50.

The auricles and ventricles of the heart contract alternately; the two auricles contracting simultaneously, as do the two ventricles. The contraction of each cavity of the heart is called

Fig. 147.—The Heart.

Fig. 147 is an external view of the heart. *a.* Left ventricle. *b.* Right ventricle. *c, e, f.* Aorta arising from the left ventricle. *g.* Arteria innominata. *h.* Left subclavian artery. *i.* Left carotid. *k.* Pulmonary artery. *l, l.* Its right and left branches. *m, m.* Veins of the lungs. *n.* Right auricle. *o.* Ascending cava. *q.* Descending cava. *r.* Left auricle. *s.* Left coronary artery. *P.* Portal veins, which return the blood from the liver and bowels.

its *systole*, and the relaxation which follows, its *diastole*. The contraction (systole) of the heart's cavities propels the blood

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What is the frequency of the heart's contractions at different periods of life? What is its Systole? Diastole?

into the arteries, causing the jet-like motion, or beating, of the artery which constitutes the pulse.

The apex of the heart being near the walls of the chest, behind the fifth and sixth ribs of the left side, produces a decided shock or jarring sensation, increased on violent exercise. This is called the *impulse* of the heart.

The *sounds* produced by the heart's action can be readily detected by placing the ear on the front part of the chest. Two sounds will be distinctly recognized, following each other in rapid succession. The first sound is more prolonged, and corresponds to the contraction of the ventricles, the pulsation of the arteries, and the impulse against the walls of the chest. The second sound is only half as long, much weaker, and corresponds to the dilatation of the ventricles and contraction of the auricles.

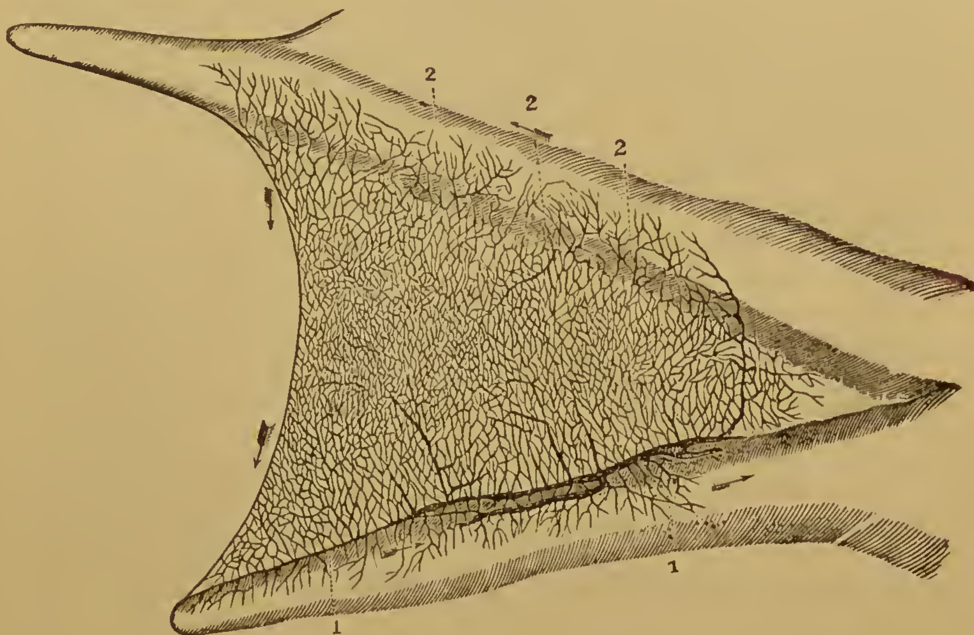

FIG. 148.—CORPUSCLES OF THE BLOOD.

In Fig. 148, A represents the blood-corpuscles as seen on their flat surface and edge. B. Congeries of blood corpuscles in columns. In coagulating, the corpuscles apply themselves to each other, so as to resemble piles of money.

The *capillary vessels* are a net work of extremely minute ves-

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What is meant by impulse of the heart? How are its sounds produced? What are capillary vessels?

sels. The capillary vascular structure exists in all organic textures and organs; indeed, all of the functional processes—secretion, excretion, assimilation, and disintegration—are performed in these microscopic tubes. Their diameter has been estimated at from 1-1000 to 1-5000 of an inch.

The area of the whole capillary system is much greater than that of the arteries and veins, hence the blood in them moves much more slowly. In its passage through the capillary vessels the blood loses much of its nutrient and life-sustaining properties, and becomes charged with the impurities and waste matters of the system, thus changing the vital fluid from arterial to venous—the very opposite of what happens in the lungs.

The *motive power* of the circulation is still a disputed problem with the physiologists, and various theories are entertained on the subject. The probability is, however, that the same motive power that moves the planets in their spheres, causes the blood to circulate—*heat*. The arrest of motion induced by friction in all parts of the body, converts motion into heat; the heat expands water into vapor, which augments its volume nearly fifteen hundred times. This production of vapor makes a force that must move the blood in some direction or explode the vessels. The valves of the heart and veins prevent its re-

Fig. 149.—The Capillary System.

Fig. 149 represents the anastomoses of the blood-vessels which form the capillaries, as seen in the web of a frog's foot by the aid of the microscope. 1, 1. The veins. 2, 2, 2. The arteries.

trograde motion, and so it moves of necessity in the direction of the arteries. The heat thus generated and used, is reconverted into motion by respiration and radiation.

The *coagulation* of the blood out of the body affords a good illustration of one of the primary laws of organic as contradistinguished from inorganic, matter—the law by which the molecules, or atoms, are arranged in the building of living tissues, as represented in the cut.

What is the motive power of the heart? What does coagulation of the blood illustrate?

Though the blood is the immediate source from which all the tissues, structures, and organs are nourished, some structures —as the tendons, ligaments, cartilages, etc.—do not contain red blood. The coloring matter of the blood, therefore, has no relation to nutrition; indeed, there is reason to believe that the *white corpuscles* of the blood are the only vitalized and nutrient elements, the red corpuscles being really dead and waste matter.

The following table shows, at a glance, the constituents of human blood in living and dead bodies:

Living Blood.	Fibrin, Albumen, Salts,	In solution, forming Liquor Sanguinis.
	Corpuscles	—Suspended in Liquor Sanguinis.
Dead Blood.	Fibrin, Corpusc's,	Crassamentum, or clot.
	Albumen, Salts,	In solution, forming serum.

What relation has the coloring matter of the blood to nutrition? What relation has the white corpuscles?

CHAPTER XII.

SECRETION AND EXCRETION.

The terms secretion and excretion are often employed interchangeably, even in medical books; but this is certainly a misuse of language. The words represent vital processes as distinct and as opposite as do the terms, assimilation and disintegration. Secretions are fluids produced from the elements of the blood for use in forming the structures from the food-material; whereas excretions are effete or waste matters resulting from the disorganization of the living structures.

The Secretions are the saliva, produced by the salivary glands; the gastric-juice, furnished by the mucous coat of the stomach; the pancreatic-juice, formed by the pancreas, and the sero-mucus (I introduce this term because medical technology does not furnish any term), produced on the surfaces of all serous and mucous membranes — the serous membranes lining all closed cavities, as those of the chest, abdomen, and joints, and the mucous membranes lining all canals and cavities which open externally, or lead to such opening.

A fluid analogous to, if not identical with, the sero-mucus secretion, is also produced by innumerable glands and follicles distributed along the course of membranous surfaces, and more numerously aggregated and enlarged wherever increased or special functional duty is required, and also at or near all the inlets and outlets of the body.

The *spleen*, *thymus* and *thyroid glands*, and *supra-renal capsules* (whose functions the physiologists do not profess to understand), are probably, in one sense, secreting organs. They have no canal or duct through which any formative fluid can be conveyed, but may be appendages to the nutritive organs, and furnish to the organic nervous system an additional

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How do secretions and excretions differ? How many secretions are there? What are they?

supply of nervous influence, whatever that may be. Be this suggestion correct or otherwise, all the known data of anatomy and physiology, and all the phenomena of pathology, accord with the theory.

There are three kinds of secreting and excreting structures. The simplest kind is that of the *membrane*, which is abundantly supplied with vessels and nerves, and covered with an epithelium (a structure resembling the scarf-skin, or cuticle, but much more delicate), as the serous and synovial membranes; another kind is that of the *follicle*, which is formed by the depression or inversion of the membrane; the third kind is that of the *gland*, which is an aggregation of follicles. If the follicles which constitute the gland are more and more convoluted and complicated in structural arrangement, it is termed *conglobate* or *conglomerate*, the simplest form being termed *globate*.

Fig. 150.

Glandular Secretion.

The structure of a gland is wonderfully minute and complicated, even though it be but globate; so much so that no dissection nor microscopical examination has yet been able to demonstrate the ultimate arrangement of its fibres, much less of its molecules and atoms. Fig. 150 is a representation of the follicles of a secreting gland multiplied and clustered together upon efferent (outgoing) ducts common to several of them, the several ducts converging to form the main duct, and the whole constituting the glandular structure.

The important and essential agents in secretion are *cells*, which are developed on the lining membrane of the follicles; and these cells, as in the case of nutrition, are constantly cast off and reproduced.

The *Excretory* organs are the *lungs*, *skin*, *liver*, *kidneys*, and *bowels;* and the *excretions* are respectively, *carbonic acid gas*, *sweat*, *bile*, *urine*, and *feces.* All of the excretory organs are capable of vicarious duty to some extent—without which pro-

How many kinds of secreting and excreting structures are there? What are excretory organs?

vision, life could not long be maintained under the ever-changing vicissitudes of temperature, and other external influences. Thus, when the skin is torpid or chilled, the lungs and kidneys especially, and to some extent the bowels and liver, excrete the perspirable matter; and when the liver is congested or inactive, the skin and kidneys especially, and to some extent the lungs and mucous surfaces, depurate the biliary elements.

There are distributed along the mucous membrane of the alimentary canal, clusters of glands which excrete fecal and other putrescent elements from the blood; of this character, probably are *Brunner's glands* in the duodenum, and *Peyer's glands* in the jejunum and ilium. Numerous folds or convolutions of mucous membrane, termed the *follicles of Lieberkühn*, are distributed through the whole length of the

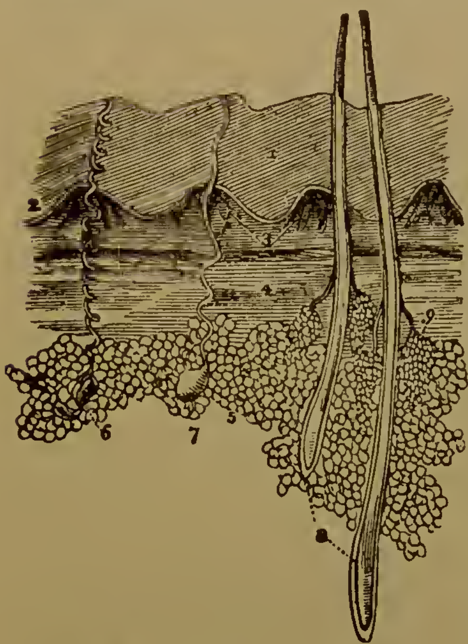

FIG. 151.—ANATOMY OF THE SKIN.

In Fig. 151 are seen—1. The epiderma. 2. Its deep layer, the rete mucosum. 3. Two of the quadrangular papillary clumps composed of minute conical papillæ, such as are seen in the palm of the hand or sole of the foot. 4. Deep layer of the derma, the corium. 5. Adipose cells. 6. A sudoriparous gland with its spiral duct, as are seen in the palm of the hand and sole of the foot. 7. Another sudoriparous gland with a straighter duct, such as is seen in the scalp. 8. Two hairs from the scalp, inclosed in their follicles; their relative depth in the skin is preserved. 9. A pair of sebiparous glands, opening by short ducts into the follicle of the hair.

intestinal canal. They are especially numerous in the small intestines; they excrete a tenacious mucus and are so large in the cæcum and rectum as to produce slight elevations on their surfaces.

The excretory function of the lungs has already been explained in the chapter on Respiration. The *sweat glands* have been estimated at seven millions. Their normal excretion is

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Can you illustrate vicarious excretory duly? How many sweat glands are there?

evaporated from the surface as rapidly as it is produced, hence normal perspiration is *insensible*. Sweating in the manner of *sensible* perspiration only occurs in abnormal conditions, or when in consequence of a humid atmosphere, the sweat accumulates on the skin.

The cutaneous excretory structures include the *meibomian follicles*, which are seated in the tarsal cartilages, and produce the viscid, gummy fluid of the edges of the eyelids; the *ceruminous*, which forms the thick resinous substance termed *ear-wax;* the *sebaceous glands*, which excrete an adipose or oily matter, and the *sudoriferous glands*, which excrete the perspirable matter proper.

The arrangement of the cutaneous excreting structures, as well as that of the hairs, is shown in Fig. 151.

The hair, nails, perspiratory glands and ducts, and *sebiferous*

Fig. 152 shows the anatomy of a portion of the skin taken from the palm of the hand. 1. Papillary layer, marked by longitudinal furrows (2), which arrange the papillæ into ridges. 3. Transverse furrows, which divide the ridges into small quadrangular clumps. 4. The rete mucosum raised from the papillary layer and turned back. 5, 5. Perspiratory ducts drawn out straight by the separation of the rete mucosum from the papillary layer.

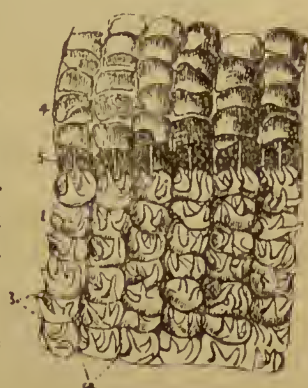

FIG. 152.—INTEGUMENT OF THE HAND.

glands (a generic term, including the sebaceous and ceruminous glands, and meibomian follicles), are termed in anatomy, *appendages of the skin*. The *pores* of the skin are the openings of the perspiratory ducts, hair follicles, and sebiferous glands, through the *epiderma*, or cuticle. This structure, with that of the *derma*, or true skin, is represented in Fig. 152.

The *liver*, being the largest organ in the body, must have an important function to perform. The bile is considered by a majority of physiologists as both a secreting and excreting organ ; if so, it is certainly a physiological anomaly. But the weight of argument is on the side of its harmony with the gen-

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Is normal perspiration sensible? What are the cutaneous excretory structures? What are sebiferous glands ?

eral organic arrangement, which makes the bile wholly excrementitious.

Late physiologists, having detected a saccharine substance in the liver (which might have been abnormal, or a product of the process of analysis,) have concluded that the liver is a sugar-making organ: and from this supposed fact some physicians have deduced the unhygienic rule that we should eat sugar. The practice does not follow from the theory. We should no more eat sugar because the liver manufactures it than we should eat bile because the liver manufactures that.

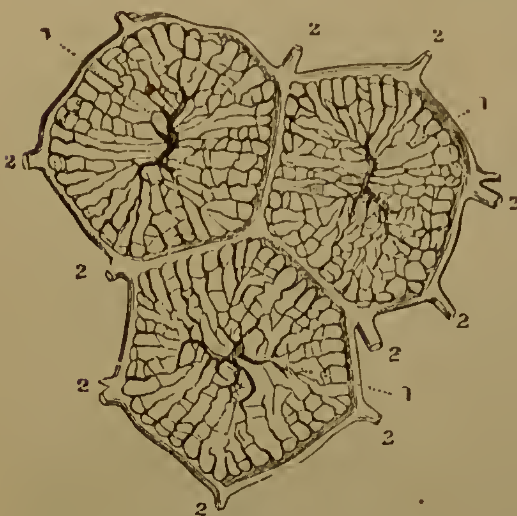

FIG. 153.—LOBULES OF THE LIVER.

The minute anatomy of the liver is represented in Fig. 153, which is a horizontal section of three superficial lobules, showing the two principal systems of blood-vessels.

The *kidneys*, which excrete the more earthy and saline matters of the disintegrated tissues, are dense and fragile in structure, and when divided present an external *vascular*, and an internal *medullary* substance. The medullary or *tubular* portion is formed of pale-reddish conical masses, and the vascular or *cortical* portion, of blood-vessels and plexiform convolutions, of uriniferous tubuli, which not only constitute the surface, but dip between the cones and surround them nearly to their apices.

The *cones*, or pyramids, are composed of straight and exceedingly minute uriniferous tubes, not more than a fine hair in diameter; these tubes commence at the apices of the cones, and surround them nearly to their apices.

The minute structural arrangement of the kidney is shown in Fig. 154.

The *bowels*, as already stated, have several clusters of glands

Is the liver a secreting or excreting organ, or both? What of its sugar-making function?

which excrete fecal matters from the blood, while they expel directly all matters that are indigestible and cannot be absorbed. The intestinal canal is divided into the *small* and *large* intestines; the former are subdivided into the *duodenum*, *jejunum*, and *ilium*, and the latter into the *cæcum*, *colon*, and *rectum*, the whole constituting a continuous tube some thirty feet in length, so convoluted and curved upon itself that whatever passes must be transported a very circuitous route, and in some places ascending contrary to the law of gravitation—a fact which proves conclusively that the living system acts on its contents, not the contents on the living system.

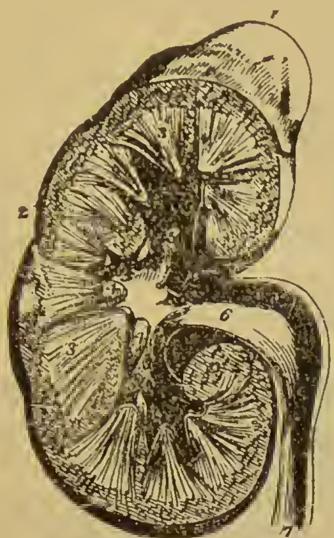

FIG. 154.—SECTION OF THE KIDNEY.

All effete or waste matters of the system, if not duly eliminated, become impurities—are become causes of disease ; and in this sense are precisely analogous in effect to poisons directly introduced into the body. And there is probably no more prolific source of numerous and complicated maladies in civilized life than retained fecal matters, constituting what is usually termed constipation of the bowels.

How are the bowels divided anatomically ? What is the effect of retained excretions ? What of constipation ?

CHAPTER XIII.

THE SPECIAL SENSES.

Smelling, seeing, hearing, tasting, and feeling, are termed special or external senses; their organs constitute the instruments of communication with all other objects in the universe, and their functions consist in the recognition of our relation to other things and other beings. Seeing and hearing recognize the nature and motion of distant objects, while smelling, tasting, and feeling take cognizance only of objects, particles, or atoms in contact with the living organism.

SMELLING.

The *nose* is the aggregate of the external parts of the organ of smell, and the *nasal fossæ* constitute the internal parts.

The *nose* is divided anatomically into the nostrils, which overhang the mouth; the *columna* or partition between the nostrils, the *vibrissæ*, stiff hairs projecting across the openings, and guarding their entrance from dust and other injurious matters, the fibro-cartilaginous *integument* forming the *tip* and *wings* of the organ, termed respectively *lobulus* and *alæ*, or *wings*, *bones*, *muscles*, *nerves*, *blood-vessels*, and the *mucous membrane* which lines its internal parts. The *nasal fossæ* are two irregular cavities, extending backward from the nose to the pharynx. On the out-

FIG. 156.—NASAL CARTILAGES.

Fig. 155 shows the fibro-cartilages of the nose. 1. One of the nasal bones. 2. Fibro-cartilage of the septum. 3. Lateral fibro-cartilage. 4. The alar fibro-cartilage. 5. Central portions of the alar fibro-cartilages, which constitute the columna. 6. Appendix of the alar fibro-cartilage. 7. Nostril.

What do you understand by the special senses? What are the anatomical divisions of the nasal organs?

er wall of each are three projecting processes termed *spongy bones.* The mucous membrane of the nasal fossæ is termed *schneiderian*, or *pituitary*, and is continuous with the lining membrane of the alimentary canal and windpipe; it also extends along the Eustachian tube (the canal or tube between the mouth and ear, and whose office is to admit air to the internal cavity of the tympanum). Its surface in the nose and nasal fossæ is furnished with a delicate epithelium, supporting innumerable cilia, or hair-like filaments, whose motions or vibrations assist in resisting and expelling morbific matters.

Fig. 156 is a vertical section of the middle part of the cavities of the nose. 7. Middle spongy bones. 8. Superior part of the nasal cavities. 10. Inferior spongy bones. 11. Vomer. 12. Upper jaw. 13. Middle meatus. 14. Inferior meatus. 17. Palatine process of the upper jaw. 18. Roof of the mouth, covered by mucous membrane. 19. A section of the mucous membrane.

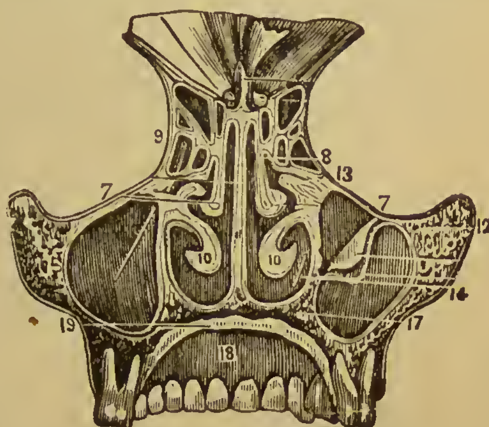

Fig. 156.—Nasal Cavities.

The ultimate filaments of the olfactory nerve terminate in papillæ on the mucous membrane, where the recognition of odors takes place.

SEEING.

Seeing consists in the recognition of external objects through the medium of the eye as the organ or instrumentality of sight. The structures of the visual apparatus are divided anatomically, into the *coats*, *humors*, and *appendages.*

The *outer coat* (first tunic) of the eyeball is formed of two essential parts, termed *sclerotic* and *cornea.* The sclerotic is the dark, fibrous membrane investing four-fifths of the globe, its anterior surface being covered with a tendinous layer (*tunica albuginea*), derived from the expansion of the tendons of the four recti muscles. A part of the tunica albuginea is covered by a mucous membrane, termed *conjunctiva*, which constitutes

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In what does seeing consist? What are the principal structures of the visual apparatus?

the "white of the eye." The cornea is the circular fifth part of the outer coat; it is transparent, and resembles a watch-glass.

The second or middle coat, or tunic, is formed of the *choroid*, a vascular membrane of a rich brown color externally, and a deep black on its inner surface; the *ciliary ligament*, a dense

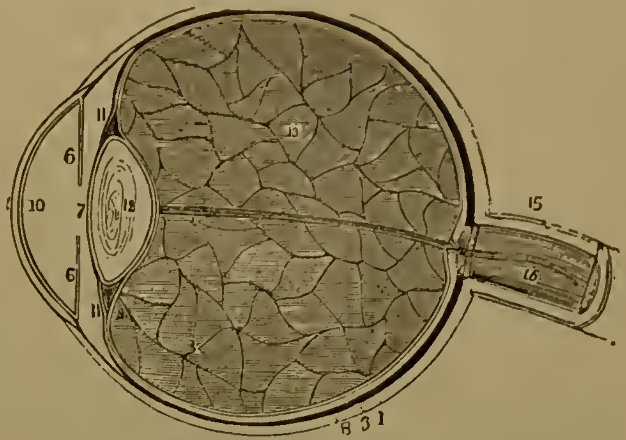

Fig. 157.—Section of the Globe.

Fig. 157 is a longitudinal section of the globe of the eye. 1. The sclerotic, thicker behind than in front. 2. The cornea, received within the anterior margin of the sclerotic, and connected with it by means of a beveled edge. 3. The choroid, connected anteriorly with (4) the ciliary ligament, and (5) the ciliary processes. 6. The iris. 7. The pupil. 8. The third layer of the eye, the retina, terminating anteriorly by an abrupt border at the commencement of the ciliary processes. 9. The canal of Petit, which encircles the lens (12); the thin layer in front of this canal is the zonula ciliaris, a prolongation of the vascular layer of the retina to the lens. 10. The anterior chamber of the eye, containing the aqueous humor, the lining membrane by which the humor is secreted is represented in the diagram. 11. The posterior chamber. 12. The lens, more convex behind than before, and enclosed in its proper capsule. 13. The vitreous humor enclosed in the hyaloid membrane, and in cells formed in its interior by that membrane. 14. A tubular sheath of the hyaloid membrane, which serves for the passage of the artery of the capsule of the lens. 15. The neurilemma of the optic nerve. 16. The arteria centralis retinæ, imbedded in the centre of the optic nerve.

white structure which surrounds the iris like a ring; the *iris*, or rainbow (so named because of its many colors in different individuals), which constitute the partition between the anterior and posterior chambers of the eye, its circular opening being the *pupil of the eye;* and the ciliary processes, which con-

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What is the iris? Why so named? The pupil of the eye? Why so denominated?

sist of triangular folds of the middle and internal layers of the choroid. They are covered with a thick black pigment.

The third tunic or inner coat of the eye is the *retina*, which

Fig. 158 is the posterior segment of a transverse section of the globe of the eye, seen from within. 1. The divided edge of the three tunics. The membrane covering the whole internal surface is the retina. 2. The entrance of the optic nerve with the arteria centralis retinæ piercing its centre. 3 3. The ramifications of the arteria centralis. 4. Foramen of Soemmering, in the centre of the axis of the eye; the shade from the side of the section obscures the limbus luteus, which surrounds it. 5. A fold of the retina, which generally obscures the foramen after the eye has been opened.

FIG. 158.—POSTERIOR SEGMENT.

is formed of three layers, the middle one termed *nervous*, being the expansion of the optic nerve.

The humors of the eye are the *aqueous*, which occupies the two chambers of the eye; the *vitreous*, which is the transparent

Fig. 159 is a dissection of the eyeball, showing its second tunic, and the mode of the distribution of the venæ vorticosæ of the choroid. After Arnold. 1. Part of the sclerotic coat. 2. The optic nerve. 3 3. The choroid coat. 4. The ciliary ligament. 5. The iris. 6 6. The venæ vorticosæ. 7 7. The trunks of the venæ vorticosæ at the point where they have pierced the sclerotica. 8 8. The posterior ciliary veins, which enter the eyeball in company with the posterior ciliary arteries, by piercing the sclerotic at 9. 10. One of the long ciliary nerves, accompanied by a long ciliary vein.

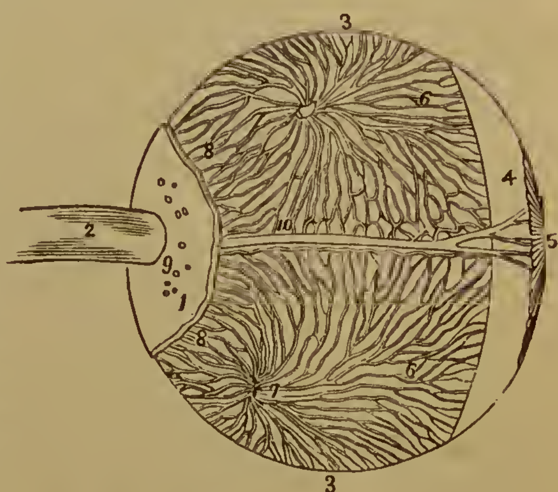

FIG. 159.—DISSECTION OF THE EYEBALL.

glassy fluid constituting the greater portion of the bulk of the globe of the eye, and the *crystalline lens*, which is situated behind the pupil, surrounded by the ciliary processes, and embed-

What is the structure and office of the retina? How many humors of the eye? How denominated?

ded in the front part of the vitreous humor. *The capsule of the lens* is a transparent elastic membrane which surrounds and encloses it.

The uses of the several structures of the eye may be briefly stated: The ocular group of muscles moves the eyeball in all directions; the firm sclerotic coat gives form to the organ of vision, and protects its delicate tissues; the transparent cornea furnishes a medium for the transmission of the rays of light; the choroid supports the nutritive vessels, and by means of the dark pigment on its posterior surface, absorbs the scattered rays of light that might otherwise interfere with the function of the retina in the recognition of objects; the iris regulates the quantity of light admitted through the pupil, by contracting so as to diminish its aperture when the rays are too strong,

FIG. 160.—ANTERIOR SEGMENT.

Fig. 160 is the anterior segment of a transverse section of the globe of the eye, seen from within. 1. The divided edge of the three tunics: sclerotic, choroid (the dark layer), and retina. 2. The pupil. 3. The iris, the surface presented to view in this section being the uvea. 4. The ciliary processes. 5. The scalloped anterior border of the retina.

and expanding so as to enlarge the aperture when the light is more feeble, and the humors refract the rays of light so as to present the most favorable relation of the retina to the object to be recognized.

APPENDAGES OF THE EYE.

The appendages of the eye are the *eyebrows*, *eyelids*, *eyelashes*, *conjunctiva*, *cavuncula lachrymalis*, and the *lachrymal apparatus*. They are represented in Fig. 161.

The eyebrows (*supercilia*) are projecting arches of integument, covered with short, thick hairs. The eyelids (*palpebræ*) are valvular layers in front of the eye; the elliptical space between is divided into *outer* and *inner canthus*. The trian-

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What are the uses of the several structures? What are the appendages of the eye?

gular portion of the inner canthus near the nose is termed *lacus lachrymalis.* The *lachrymal canals*, between the eyes and nose, commence on each side of small papillæ in the lacus lachrymalis. The thin fibro-cartilaginous bands which support the edges of the eyelids are termed the *tarsal* cartilages; the *Meibomian glands*, which produce the viscid matter of the eyelids, are embedded in the internal surface of the tarsal cartilages.

The eyelashes (*cilia*) are triple rows of long, thick hairs, curl-

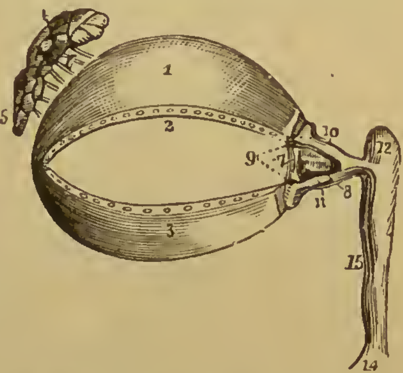

FIG. 161.—APPENDAGES OF THE EYE

Fig. 161 is a representation of the appendages of the eye. 1. The superior tarsal cartilage. 2. The lower border of the cartilage, on which are seen the openings of the Meibomian glands. 3. The inferior tarsal cartilage; along the upper border of this cartilage the openings of the Meibomian glands are likewise seen. 4. The lachrymal gland—its superior or orbital portion. 5. Its inferior or palpebral portion. 6. The lachrymal ducts. 7. The plica semilunaris. 8. The caruncula lachrymalis. 9. The puncta lachrymalia of the lachrymal canals. 10. The superior lachrymal canal. 11. The inferior lachrymal canal. 12. The lachrymal sac. 14. The dilatation of the nasal duct, where it opens into the inferior meatus of the nose. 15. The nasal duct.

ing from each other on the eyelids, so as to obviate interlacing. The *conjunctiva*, which covers the anterior surface of the eye, is reflected on the lids so as to form their inner layer. A small, reddish body occupying the lacus lachrymalis at the inner canthus is termed *caruncula lachrymalis.* On the outer side of the caruncula is a fold of the conjunctiva, termed *plica semilunaris*, which in birds is the *membrana nicitans.*

The lachrymal apparatus consists of the *lachrymal gland*, which produces the tears at the outer and upper part of the orbit; the *puncta lachrymalia*, small openings in the lachrymal papillæ; the *lachrymal canals*, which commence at the puncta lachrymale, and run inward to the lachryma sac; the *lachrymal sac*, which constitutes the upper extremity of the nasal duct, and the *nasal duct*, a short canal, less than an inch in length, running downward, backward, and outward to the inferior meatus of the nose, terminating in an enlarged orifice.

What is the lacus lachrymalis? Lachrymal canals? Meibomian glands? Eyelashes? Conjunctiva? Lachrymal gland? Nasal Duct?

The Special Senses.—Hearing.

The organ of hearing is divided anatomically into

I. The External Ear.

II. The Tympanum, or Middle Ear.

III. The Labyrinth, or Internal Ear.

The principal parts of the *external ear* are the *pinna*, forming its prominent rim and the cartilaginous plate, which is funnel-

Fig. 162.—Structure of the Ear.

Fig. 162 is a representation of all parts of the ear. 1. Meatus auditorius externus. 2. Drum of the ear, or tympanum. 3, 4, 5. The bones of the ear. 7. Vestibule, the central part of the labyrinth. 8, 9, 10. The semi-circular canals. 11, 12. The channels of the cochlea. 13. Auditory nerve. 14. Eustachian tube, the channel from the middle ear to the throat.

shaped to collect the vibrations of air, and the *meatus*, the tube which conveys them to the drum of the ear—tympanum.

The *meatus auditorius* is about an inch in length, extending inward and a little forward; in the substance of its lining membrane are the *ceruminous glands*, which excrete the ear-wax.

What are the divisions of the ear? What do you understand by meatus? Ceruminous glands?

Short, stiff hairs stretch across the meatus to prevent the ingress of dust and insects.

The *tympanum* is an irregular bony cavity within the petrous or most solid portion of the temporal bone. It is bounded externally by the membrana tympani, and is filled with air, which is received through the Eustachian tube.

The three bones of the ear (*malleus*, or hammer-like ; *incus*, anvil-like ; and *stapes*, stirrup-like;) are connected and held together by ligaments, and moved upon themselves by several very small muscles.

The *labyrinth*—so named in reference to the complexity of

FIG. 163.—DIAGRAM OF THE EAR.

Fig. 163 is a diagram exhibiting the principal divisions and parts of the ear. *p*. Pinna. *t*. Tympanum. *l*. Labyrinth. 1. Upper part of the helix. 2. Antihelix. 3. Tragus. 4. Antitragus. 5. Lobulus. 6. Concha. 7. Upper part of the fossa innominata. 8. The meatus. 9. Membrana tympani, divided by the section. 10. The three small bones of the ear, malleus, incus, and stapes, crossing the area of the tympanum ; the foot of the stapes blocks up the fenestra ovalis upon the inner wall of the tympanum. 11. The promontory. 12. Fenestra rotunda ; the dark opening above the bones leads into the mastoid cells. 13. Eustachian tube; the little canal upon this tube contains the tensor tympani muscle in its passage to the tympanum. 14. Vestibule. 15. The three semi-circular canals, horizontal, perpendicular, and oblique. 16. The ampullæ upon the perpendicular and horizontal canals. 17. Cochlea. 18. A depression between the convexities of the two tubuli which communicate with the tympanum and vestibule ; one is the scala tympani, terminating at 12 ; the other the scala vestibuli.

its communications — consists of a bony and a membranous portion ; the bony portion presenting a series of cavities channeled through the substance of the petrous part of the tem-

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What is the tympanum? What are the bones of the ear? What is the labyrinth?

poral bone, and divided into *vestibule*, *semi-circular canals*, and *cochlea*.

The *membranous labyrinth* is a counterpart of the vestibule and semi-circular canals, but smaller in size. Its cavity is filled

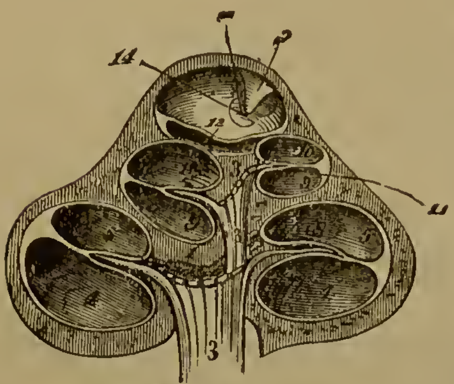

FIG. 164.—THE COCHLEA.

Fig. 164 shows the cochlea divided parallel with its axis through the centre of the modiolus. 1. Modiolus. 2. The infundibulum. 3, 3. Cochlear nerve. 4, 4. The scala tympani of the first turn of the cochlea. 5, 5. Scala vestibuli of the first turn; the septum between 4 and 5 is the lamina spiralis. 8. Loops formed by filaments of the cochlear nerve on the lamina spinalis. 9, 9. Scala tympani of the second turn of the cochlea. 10, 10. Scala vestibuli of the second turn. 11. Half turn of the scala vestibuli; the dome over it is the cupola. 14. Helicotrema; a bristle is passed through it, in front of which is the hamulus.

with a limpid fluid, and contains two small calcareous bodies termed *otoconites*.

The whole structural arrangement of the ear, like that of all

FIG. 165.—THE LABYRINTH.

Fig. 165 is the labyrinth of the left ear, laid open to exhibit its cavities and the membranous labyrinth. 1. Cavity of the vestibule. 2. Ampulla of the superior semi-circular canal. 4. The superior canal, with its contained membranous canal. 5. Ampulla of the inferior canal. 6. Termination of the membranous canal of the horizontal semi-circular canal in the sacculus communis. 7. Ampulla of the middle semi-circular canal. 8. The same canal with its membranous canal. 9. Common canal. 10. Membranous common canal. 11. Otoconite of the sacculus communis. 12. Sacculus proprius; its otoconite is seen through its membranous parieties. 13. First turn of the cochlea. 14. Extremity of the scala tympani, corresponding with the fenestra rotunda. 15. Lamina spiralis. 18. Half turn of the cochlea. 19. Lamina spiralis, terminating in its falciform extremity. The dark space included within the falciform curve of the extremity of the lamina spiralis is the helicotrema. 20. The infundibulum.

What are the divisions of the labyrinth? What are otoconites?

the other organs of external sense, shows it to be an apparatus for *recognition*, and not for mere reception. Sound is not the "vibrations of air upon the drum of the ear," but the recognition, by the mind, of the motions of an object, through the medium of the auditory apparatus, just as the mind recognizes distant objects through the medium of the eye. Vibrations of air are essential to sound, but are not themselves sound. The moving body, as when a bell is struck, causes vibrations in the air, and the force and rapidity of these vibrations are recognized as *noises*, more or less distant, and pleasant or unpleasant, concordant or discordant, as the case may be. Voice, speech, singing, and instrumental music of all kinds, are but mental recognitions of the mode of motion of the "sounding body."

The rationale of sound may be better understood by reference to the diagram, fig. 166.

When the tongue, *a*, strikes the side at *b*, the side springs out to *c*, changing the form of the bell from a circle to an ellipse. When the bell springs back to its original form, its sides retract and expand in the opposite direction, as a vibrating string rebounds beyond its centre or starting-point ; and so alternately, making a succession of what are termed "sonorous waves," which gradually diminish in force as the vibrations lessen in extent, until they cease to be recognized by the ear. The "perception of sound" is the mental recognition of these vibrations of the air by the instrumentality of the auditory apparatus; hence, where there is no ear there can be no sound.

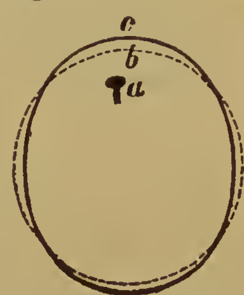

FIG. 166. — VIBRATING BELL.

The "Hydropathic Encyclopedia" says :

"The primitive sounds of the musical scale are derived from the different forces or kinds of vibration. Thus, when a bell is struck, the first full, loud sound is the fundamental or key note. When the force of the blow is partially spent, there is a different degree of motion, producing a different force of

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What is the rationale of sound? How may this be illustrated?

atmospheric vibration, and occasioning a modified perception of sound; and when the vibrations have decreased still further in intensity, a third primitive sound is recognized.

"A musical *chord* is the combined sound of several sounds produced simultaneously. When the effort is pleasant to the ear, these chords are called *concords;* and when unpleasant, *discords.* The most pleasing concords are produced when the greatest number of vibrations in a given time occur together; and the most disagreeable discords, when the fewest vibrations take place simultaneously.

"A good idea of concord may be gathered from the following illustration:

FIG. 167.—MUSICAL CHORD.

"On counting the waved lines, it will be found that every third vibration of the sound represented by the upper line, and every second vibration of the sound represented by the under line, come together, the conjunction being denoted by the dotted cross-lines. According to the greater or less frequency of these coincident vibrations, are the sounds concordant or discordant. The most agreeable concord is, of course, that where every vibration of one sound and every other vibration of another sound come together."

TASTING.

The tongue is usually termed the organ of taste; but the papillæ of the mucous membrane of the tongue, soft palate, and fauces, are instruments of taste, although those of the tongue are more acutely sensitive.

The muscular fibres of the tongue being longitudinal, transverse, oblique, and vertical, afford it every possible variety of motion, while its terminal point, or tip, approximates the skin in structure, and, like it, is an instrument of touch or feeling.

Simple as is the function of taste, its principal organ, the tongue, is a highly complex structure.

Solid substances in contact with the tongue, or mucous membrane of the mouth, are only felt, not tasted. Solubility of

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What is a musical chord? What is the rationale of discords? What are instruments of taste?

the matter in contact is essential to taste. The sense of taste may also be excited by mental impressions, and by mechanical and chemical irritants.

The purpose of the function of taste is to direct us in the selection of food; and an ability to appreciate and enjoy healthful alimentary substances is in the exact ratio of the integrity of the organ; but when perverted or depraved by alcohol, tobacco, pungent condiments,

The tongue and its papillæ are seen in Fig. 168. 1. The raphe, which sometimes bifurcates in the dorsum, as in the figure. 2, 2. Lobes of the tongue; the rounded eminences on this part of the organ and near its tip are the fungiform papillæ; the smaller papillæ, among which the former are dispersed, are the conical and filiform papillæ. 3. Tip of the tongue. 4, 4. It sides, on which the papillæ are arranged in fringed and lamellated forms. 5, 5. The A-shaped row of papillæ circumvallatæ. 6. Foramen cœcum. 7. Mucous glands at the root of the tongue. 8. Epiglottis. 9, 9. Fræna epiglottidis. 10, 10. Greater cornua of the hyoid bone.

or unwholesome ingesta of any kind, it is no longer a guide, and may crave the most indigestible and unhealthful viands.

FIG. 168.—THE TONGUE.

FEELING.

The skin is the organ of touch. Through the medium of the integument of the bodily organization, the mind recognizes the form and properties of bodies in contact—their size, form, density, etc.

The skin is continuous with the mucous membrane of the internal canals and cavities, the two structures blending together in arrangement and function at all of the inlets and outlets of the body. It is composed of two layers, the derma, or true skin, and the epiderma, or scarf-skin.

The *derma* (*cutis*) is composed chiefly of elastic cellulo-fibrous

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What is essential to taste? How may taste be excited? Of what layers is the skin composed?

tissue, abundantly supplied with blood-vessels, nerves, and lymphatics.

The *epiderma* (*cuticle*) envelopes and protects the derma ; its external surface is hard and horny, resembling the scales of a fish ; its internal surface is soft and cellular, and is termed *rete mucosum*.

The nerves of feeling are derived from the posterior roots of the spinal, and fibres of the fifth and eighth pair of cerebral nerves. They are distributed to the papillæ of the skin which are small elevations enclosing loops of blood-vessels and branches of sensory nerves, situated on the external surface of the true skin (*cutis vera*).

Fig. 169 is a representation of the papillæ of the palm of the hand, the cuticle being removed.

When external objects come in contact with the sensitive surface, the only mental recognition is that of resistance, the degree of which determines the idea of their hardness or softness. When, in consequence of the contact, the sensory papillæ are moved upon each other, there is a mental recognition of extension, space, roughness, smoothness, and other mechanical properties.

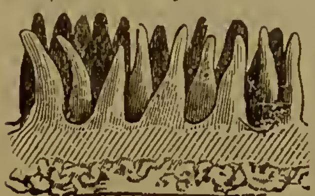

Fig. 169. — Cutaneous Papillæ.

The knowledge of *form* and *weight* some late physiologists have been unable to account for by the ordinary sense of touch, and have got out of the difficulty by supposing a sixth sense, which they call the *muscular sense*, to exist for that particular purpose. The sense of *temperature* has also been attributed to a distinct set of nerves, because the recognition of it occurred without the actual contact of the hot or cold body with the sensory surface. I do not see that either supposition makes the matter any clearer. Form and weight are but degrees of extension and resistance, and temperature, whether its essential nature is caloric, light, or electricity, is but the perception of rays or particles coming in contact with the sensory surface, and expanding or contracting, that is to say,

From what sources are the nerves of feeling derived? What does feeling recognize?

moving the contractile tissues so as to *impress* the nervous papillæ.

The sense of touch is developed in different parts in proportion to the supply of sensory nerves. In man the acuteness of the sense varies in different regions of the body. The lips, tip of the tongue, and inside of the last joints of the fingers are exquisitely sensitive, in consequence of the nerves being very numerous and superficially distributed. The epidermis is also very thin in those parts, and the innumerable lines and furrows afford the papillæ a greater degree of isolation. The development of the sense corresponds with the number and extent of these lines and furrows. The sense of touch, like all the special senses, may be educated to a surprising degree of acuteness and accuracy, as with the blind, who have been taught to read and even distinguish colors by it.

What is the cause of the acuteness of sensibility? Can the sense of feeling be educated?

CHAPTER XIV.

THE NERVOUS SYSTEM—NEUROLOGY.

The nervous tissue of living organisms performs the functions of feeling and thinking. In man and in the higher animals the nervous system consists of two very distinct subsystems, one pertaining to mentality and the other to vitality. These divisions of the nervous system are so intimately related and interblended that each may communicate with and modify the action and condition of the other. It is because of this intercommunication between the nerves of organic life and those of the mental powers, that bodily derangements disturb the mental functions, and that mental impressions influence the bodily functions, affording thus a philosophical basis for the oft quoted, but seldom regarded, hygienic maxim, "*Mens sana in corpore sano.*"

THE NERVOUS TISSUE.

The nerves constitute the highest order of organized matter. It is the medium through which the mind is related to the muscles and to the external world. The nervous structure is composed of two kinds of matter, one of which is *white*, *medullary*, or *fibrous*, and the other *gray*, *cineritious*, or *vesicular*. Wherever these two kinds of matter are united, they constitute a nervous center. In the brain the gray matter is external, while in the spinal cord the reverse is the case.

The ultimate nerve fiber is of tubular form, consisting of an external delicate membrane and a soft internal substance, as represented in Fig. 170.

Microscopical observations have divided the elements of the nervous system into *white fibers*, *gray fibers*, *cells*, and *granules*.

What are the functions of nervous tissue? What are the distinctions of nervous matter?

Fig. 171 is a diagram of the arrangement and distribution of the cerebro-spinal nerves.

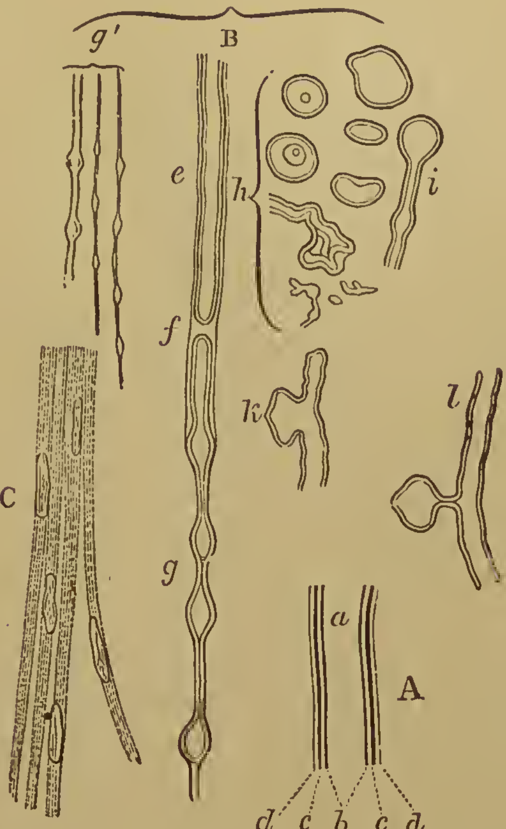

FIG. 170.—TUBULAR FIBER OF SPINAL NERVE.

Fig. 170 is a diagram of tubular fiber of a spinal nerve. *a*. Axis cylinder. *b*. Inner border of white substance. *c*, *c*. Outer border of white substance. *d*, *d*. Tubular membrane. B. Tubular fibers; *e*, in a natural state, showing the parts as in A. *f*. The white substance and axis cylinder interrupted by pressure, while the tubular membrane remains. *g*. The same with varicosities. *h*. Various appearances of the white substance and axis cylinder forced out of the tubular membrane by pressure. *i*. Broken end of tubular fiber, with the white substance closed over it. R. Lateral bulging of white substance and axis cylinder, from pressure. *l*. The same, more complete. *g*. Varicose fibers of various sizes, from the cerebellum. C. Gelatinous fibers from the solar plexus, treated with acetic acid, to exhibit their cell nuclei. B and C are magnified 320 diameters.

From the "Hydropathic Encyclopædia" is copied the follow-

What is the structure of the ultimate nerve-fiber?

ing brief but lucid explanation of the elements of the nervous structure:

"*White nerve-fibers* compose most of the brain, spinal cord, and cerebro-spinal nerves, and enter into the structure of the organic system. They terminate in the various internal organs, at the surface of the body, and in the substance of the cerebro-spinal axis, by forming loops. In size they vary from $\frac{1}{2000}$ to $\frac{1}{14000}$ of an inch in diameter.

FIG. 171.—THE NERVOUS SYSTEM.

"*Gray nerve-fibers* are smaller in diameter, and less transparent. They constitute the principal part of the organic system, and are also present in the cerebro-spinal nerves, most abundantly in those of sensation.

"The *nerve-cells* vary from $\frac{1}{300}$ to $\frac{1}{1250}$ of an inch in diameter. They are composed of a capsular sheath, containing a reddish-gray granular substance, and one or more nuclei and nucleoli, the nucleus being attached to the sheath. Nerve-cells are found in the gray substance of the brain and spinal cord, in the ganglions of the cerebro-spinal nerves, and in the organic nerves and their ganglia. From the circumference of the nerve-cells arise one or more delicate thread-like processes, from $\frac{1}{1000}$ to $\frac{1}{10000}$ of an inch in diameter, which are the origins of the gray nerve-fibers.

"The *nerve-granules* exist in the forms of minute homogene-

What do white nerve-fibers compose? Gray nerve-fibers? Of what are nerve-cells composed? Nerve granules?

ous particles, aggregated particles, and nucleated corpuscles, varying in diameter between $\frac{1}{5000}$ and $\frac{1}{15000}$ of an inch. They serve as a bond of connection between the fibers and cells of the brain and spinal cord, and enter into the various ganglia.

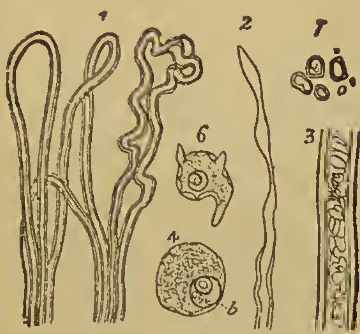

FIG. 172.—MINUTE NERVOUS STRUCTURE.

Fig. 172 represents the microscopic elements of the nervous structure. 1. Mode of termination of white nerve-fibers in loops; three of these loops are simple, the fourth is convoluted. The latter is found in situations where a high degree of sensation exists. 2. A white nerve-fiber from the brain, showing the varicose or knotty appearance produced by traction or pressure. 3. A white nerve-fiber enlarged to show its structure, a tubular envelope and a contained substance—neurilemma and neurine. 4. A nerve cell showing its composition of a granular-looking capsule and granule contents. 5. Its nucleus containing a nucleolus. 6. A nerve-cell, from which several processes are given off; it contains also a nucleated nucleus. 7. Nerve-granules.

"A *nerve* is a collection of nerve-fibers into small bundles, or fasciculi, each fasciculus being invested by a distinct neurilemma. Several of these fasciculi are again collected into larger bundles, which are also enclosed in a separate neurilemma; then again the larger fasciculi are collected into a grand bundle, which is enclosed in a general neurilemma, or sheath of white fibrous tissue."

The external surface of the cerebrum is seen in Fig. 173. *a*, *a*. The scalp turned down. *b*, *b*. Cut edges of the skull bones. 3. The dura mater suspended by a hook. 4. The left hemisphere.

FIG. 173.—THE BRAIN EXPOSED.

What function do nerve-granules perform? Of what does a nerve consist?

PRIMARY DIVISIONS OF THE NERVOUS SYSTEM.

For convenience of description, the nervous system may be considered under three primary divisions.

1. The Brain Nervous System.
2. The Organic Nervous System.
3. The Reflex Nervous System.

THE BRAIN NERVOUS SYSTEM.

That the brain is the organ of mind, is now admitted by all respectable physiologists. According to phrenology, the brain consists of a plurality of organs, different portions of its substance being appropriated to different recognitions and consti-

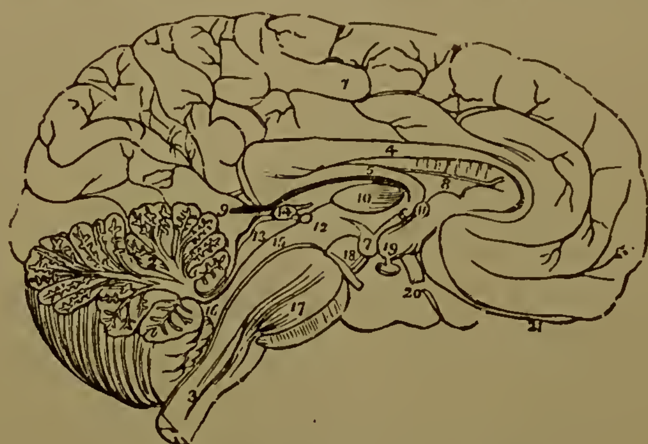

FIG. 174.—MESIAL SURFACE OF THE BRAIN.

Fig. 174 represents the mesial surface of a longitudinal section of the brain. 1. Inner surface of the left hemisphere. 2. Divided centre of the cerebellum. showing the arbor vitæ. 3. Medulla oblongata. 4. Corpus callosum. 5. Fornix. 6. One of the crura of the fornix. 7. One of the corpora albicantia, pea-shaped bodies between the crura cerebri. 8. Septum lucidum. 9. Velum interpositum. 10. Section of the middle commissure in the third ventricle. 11. Section of the anterior commissure. 12. Section of the posterior commissure. 13. Corpora quadrigemina. 14. Pineal gland. 15. Aqueduct of Sylvius. 16. Fourth ventricle. 17. Pons Varolii, through which are seen passing the diverging fibres of the corpora pyramidalia. 18. Crus cerebri of the left side; the third nerve arising from it. 19. Tuber cinereum, from which projects the infundibulum, having the pituitary gland appended to its extremity. 20. One of the optic nerves. 21. The left olfactory nerve terminating anteriorly in a rounded bulb.

What are the primary divisions of the nervous system? What is the function of the brain?

tuting distinct mental powers. The convolutions of the brain certainly favor the theory of the phrenologians.

The brain, which is the mass of nervous *substance* occupying the cavity of the cranium, is divided into the *cerebrum*, *cerebellum*, and *medulla oblongata*. It has three investing membranes: the *dura mater*, which is external, strong, and fibrous ; the middle, termed *arachnoid*, which is thin and transparent, and the *pia mater*, the internal covering, which consists of innumerable blood-vessels held together by a thin layer of cellular tissue. The brain and its coverings together constitute the *encephalon*.

THE CEREBRUM.

The cerebral portion of the brain is divided into *right* and *left hemispheres*, and each hemisphere is subdivided into *anterior*, *posterior*, and *middle lobes*. There are also many parts or subdivisions of the different portions of the brain, described minutely in the works on Anatomy, but are not important except to the scientific teacher.

All of the mental powers, with a single exception, that of amativeness, are manifested by the cerebrum, its anterior portion manifesting the perceptive and reflective faculties, and the superior, posterior, and inferior portions the affectuous, mind, or feelings—these being grouped and subdivided into the moral emotions, domestic affections, and self-relative propensities.

THE CEREBELLUM.

The *cerebellum* constitutes in man one-seventh to one-sixth of the whole brain. Like the cerebrum, its external surface is composed of gray cells, and its internal substance of white fibrous matter. Its two hemispheres are united by the commissure termed *pons Varolii;* this consists of transverse fibres, separated into two layers by the fascicula of the *corpora pyramidalia* and *corpora olivaria*. The *crura cerebelli* is constituted of the union of these layers.

It seems to be well settled by the investigations of late physiologists, that one of the functions of the cerebellum is to

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How is the brain divided? What membranes enclose it? What are the divisions of the cerebrum? Cerebellum?

co-ordinate and control the action of the muscles of locomotion.

THE MEDULLA OBLONGATA.

This is a conical-shaped body, extending from the pons Varolii to the upper conical vertebra (atlas), and is really the upper and enlarged portion of the spinal cord. Its fibres, which constitute the *commissures* of the brain, are connected both with the cerebrum and cerebellum. The gray and white matters of the medulla oblongata are intermixed, instead of being distinct, as in the cerebrum and cerebellum; while in the spinal cord the arrangement is reversed, the white matter being external and the gray matter internal.

THE SPINAL CORD.

The *spinal cord* (*medulla spinalis*), with its *membranes*, and the *roots* of the *spinal nerves*, is contained within the spinal or

FIG. 175.—BASE OF THE BRAIN.

In Fig. 175 are seen several sections of the base of the brain, the distribution of the diverging fibres. 1. Medulla oblongata. 2. Half of the pons Varolii. 3. Crus cerebri, crossed by the optic nerve (4), and spreading out into the hemisphere, where it is called *corona radiata*. 5. Optic nerve. 6. Olfactory nerve. 7. Corpora albicantia. 8. Fibres of the corpus pyramidale passing through the pons. 9. The fibres passing through the thalamus opticus. 10. The fibres passing through the corpus striatum. 11. Their distribution to the hemisphere. 12. Fifth nerve. 13. Fibres of the corpus pyramidale, which pass outward with the corpus restiforme into the cerebellum. 14. Section through one of the hemispheres of the cerebellum, showing a body called corpus rhomboideum in the centre of its white substance, and the arbor vitæ. 15. The opposite hemisphere.

What is the situation of the medulla oblongata? How do its fibres differ from those of the encephalon?

vertebral column, extending from the base of the skull to the *os coccygis.* Its outer membrane (*the cavertebralis*) is continuous with the dura mater of the brain; its central and internal membranes are prolongations of the arachnoid and pia mater.

The spinal cord is divided into lateral halves, and each lateral half is subdivided by a lateral sulcus into *anterior* and *posterior columns*, the anterior, according to Sir Charles Bell, giving origin to the nerves of *motion*, and the posterior to the nerves of *sensation.*

In Fig. 176 are seen the relations of the spinal cord to the medulla oblongata, pons Varolii, and cerebellum, as well as the several enlargements in its course.

A *spinal nerve* contains a bundle of *sensory* fibres passing upward to the brain, a *motor* set, conveying the influence of volition from the brain; also an *afferent* or centripetal set of fibres, terminating in the spinal cord, and taking cognizance of external objects, and an *efferent* or centrifugal set, arising from the spinal cord, terminating in the muscles, which they influence and control.

Fig. 176.
The Spinal Cord.

THE REFLEX NERVOUS SYSTEM.

The afferent and efferent nerves, with the gray matter in the center of the spinal cord, constitute what is termed the *reflex nervous system.* But the rationale of "reflex action" is explained very erroneously in the standard works on Physiology and Pathology. The error consists in assuming that external objects make "impressions" on

How is the spinal cord divided? What does a spinal nerve contain? What is the reflex nervous system?

the organs of sense, which impressions are "conveyed" to the spinal cord, and thence radiated or conveyed to the muscles. The true theory is simple enough when we understand by the term impression, *vital recognition.* The presence and qualities of the external object are recognized through the media of the sentient, or in going nerves, and the action of the muscles in relation thereto is determined by the motor, or *out-going* nerves.

All spasmodic movements of the muscular system are properly termed *reflex actions.* The producing causes may be in the spinal cord itself, or on the surface, constituting the two kinds of reflex action termed *centric* and *excentric.*

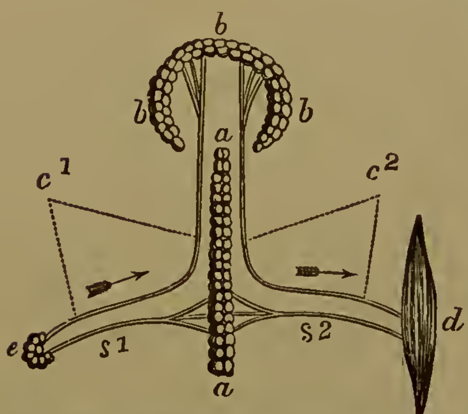

FIG. 177.—GROUPS OF NERVOUS FIBRES.

Fig. 177 is a diagram of the origins and terminations of the different groups of nervous fibres. *a. a.* Vesicular substance of the spinal cord. *b, b.* Vesicular substance of the brain. *e.* Vesicular substance at the commencement of the afferent, which consists of *c* 1, the sensory nerve passing to the brain, and *s* 1, the spinal division, or excitor nerve, which terminates in the vesicular substance of the spinal cord. On the other side is the efferent or motor nerve, consisting of two divisions, *c* 2, the cerebral portion conveying voluntary motion, and *s* 2, the spinal division conveying reflex motion.

THE CRANIAL NERVES.

There are nine pairs of cranial nerves, all of which emerge through foramina at the base of the cranium.

The *First Pair* of the cranial nerves is termed *Olfactory*, and is appropriated to the sense of *smelling.* Each arises in the brain by three roots, which are united into a bulbous mass on the cribriform plate of the ethmoid bone. From this bulbous mass (*bulbus olfactorius*) the nerves are given off which are distributed to the mucous membrane of the nose.

The *Second Pair* are the *Optic*—those of seeing. Each is a large cord arising from the thalmus opticus and tubercula quad-

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What is the true theory of reflex action? What is the function of the first pair of nerves? Second?

rigemina, winding around the crus cerebri as a flattened band, termed *tractus opticus*, and joining its fellow in front of the *tuber cinerium;* here it forms a chiasm, termed the *optic commissure*, then proceeding forward the nerve diverges from its fellow, passes through the optic foramen to the eyeball, and, passing through the sclerotic and choroid coats, expands into the *retina*, the nervous membrane of the eye.

FIG. 178.—THE NERVES CONNECTED WITH THE BRAIN.

Fig. 178 shows the origin of the cranial nerves. The numbers are placed against the corresponding pairs of nerves. 11 and 12 are spinal nerves. *a a a.* Cerebrum. *b.* Cerebellum. *c.* Medulla oblongata. *d.* Medulla spinalis. *f.* Corpus callosum.

The *Third Pair* are regarded as nerves of motion—*Motores Oculorum.* They arise from the crus cerebri, and are distribu ted to all of the muscles of the eye-ball, except the externa rectus and superior oblique. Each sends a branch to the ophthalmic ganglion, from which proceed the ciliary nerves of the iris.

The *Fourth Pair* are the smallest of the cranial nerves, and are also nerves of motion. They are termed *Patheteci.* Each

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What is the function of the third pair of nerves? Fourth pair? Why termed patheteci?

patheticus arises from the valve of the brain (valve of Viessens) and is distributed to the superior oblique muscle.

The *Fifth Pair* are termed *Trifacial*. They are the largest of the cranial nerves, and the principal nerves of sensation of the head and face. They arise, like the spinal nerves, from two roots. Each arises in front of the floor of the fourth ventricle, and, near the extremity of the petrous portion of the temporal

Fig. 179.—Trifacial Nerves.

In Fig. 179 is seen the distribution of the fifth pair of nerves. 1. Orbit. 2. Antrum of the upper jaw. 3. Tongue. 4. Lower jaw. 5. Root of the fifth pair, forming the ganglion of Casser. 6. Ophthalmic branch. 7. Superior maxillary. 8. Inferior maxillary. 9. Frontal branch. 10. Lachrymal. 11. Nasal. 12. Internal nasal. 13. External nasal. 14. External and internal frontal. 15. Infra-orbitary. 16. Posterior dentals. 17. Middle dental. 18. Anterior dental. 19. Labial and palpebral branches of the infra-orbital. 20. Orbitar. 21. Pterygoid. 22. Masseter, temporal, pterygoid, and buccal branches. 23. Lingual branch, joined at an acute angle by the chorda tympani. 24. Inferior dental, terminating in 25. Mental branches. 26. Superficial temporal. 27. Auricular branches. 28. Mylo-hyoid branch.

bone, spreads out into a large semi-lunar ganglion, termed *Casserian ;* this ganglion divides into the ophthalmic, superior maxillary, and inferior maxillary branches.

The *Ophthalmic* nerve is a short branch, only three-fourths of an inch in length, and, passing out at the sphenoidal foramen, divides into three branches, *frontal*, *lachrymal*, and *nasal*, distributed, respectively, to the conjunctiva, upper eyelid, and integument of the forehead; the lachrymal gland, temple-cheek, and inner portion of the orbit and to the anterior part of the mucous membrane of the nose, and the integument at the ex-

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What is the function of the fifth pair of nerves? How distributed?

tremity of the nose; also to various portions of different structures of the eye and its appendages.

The *Superior Maxillary* nerve is distributed to the lower eyelid and conjunctiva, muscles and integument of the upper lip, nose, and cheek, forming a plexus with the facial nerves.

The *Inferior Maxillary* is the largest division of the fifth pair. It is distributed very extensively to the temporal and maxillary regions, chin, lower lip, teeth, gums, tongue, parotid gland, and external parts of the ear.

FIG. 180.—8th PAIR OF NERVES.

In Fig. 180 is seen a representation of the origin and distribution of the eighth pair. 1, 3, 4. Medulla oblongata. 1 is the corpus pyramidale of one side. 3. Corpus olivare. 4. Corpus restiforme. 2. Pons Varolii. 5. Facial nerve. 6. Origin of the glosso-pharyngeal. 7. Ganglion of Andersch. 8. Trunk of the nerve. 9. Spinal accessory nerve. 10. Ganglion of the pneumogastric. 11. Its plexiform ganglion. 12. Its trunk. 13. Its pharyngeal branch forming the pharyngeal plexus (14), assisted by a branch from the glosso-pharyngeal (8), and one from the superior laryngeal (15). 16. Cardiac branches. 17. Recurrent laryngeal branch. 18. Anterior pulmonary branches. 19. Posterior pulmonary branches. 20. Œsophageal plexus. 21. Gastric branches. 22. Origin of the spinal accessory. 23. Its branches distributed to the sterno-mastoid muscle. 24. Its branches to the trapezius muscle.

The *Sixth Pair* are termed *Abducentes.* They are nerves of motion, and are distributed to the external rectus muscle. A paralysis of this muscle occasions internal squinting.

The *Seventh Pair* are nerves of motion, and are distributed to the face and ear; hence are termed *Facial* and *Auditory.*

How is the superior maxillary nerve distributed? Inferior maxillary? Sixth pair? Seventh pair?

The *Eighth Pair* consists of three nerves, termed glosso pharyngeal, pneumogastric, and spinal accessory. By some anatomists these divisions of the eighth pair are regarded as ninth, tenth, and eleventh pairs.

The *Glosso-Pharyngeal nerve* is distributed to the mucous membrane of the base of the tongue and fauces, tonsils, and mucous glands of the mouth.

The *Pneumogastric* nerve, as its name indicates, is distributed to the lungs and stomach; hence the division or extreme compression of its *pneumatic* branch interrupts respiration and causes instant death, while a similar condition of its *gastric* branch destroys the digestive capacity of the stomach.

The *Spinal Accessory nerve* arises from the upper portion of the spinal cord, and is distributed to the parts adjacent.

The *Ninth Pair of nerves* is termed *Hypoglossal.* They are nerves of motion, and are distributed principally to the muscles of the tongue.

THE SPINAL NERVES.

There are thirty-one pairs of nerves originating from the spinal cord. Each arises by two roots, an *anterior*, which is *motor*, and a *posterior*, which is *sensitive.* In the intervertebral foramen, the posterior roots are enlarged into a ganglion, after which both roots unite and form a spinal nerve. There they form divisions of the spinal nerves, corresponding to the four divisions of the vertebral column—*cervical*, *dorsal*, *lumbar*, and *sacral.*

There are eight pairs of *cervical nerves.* They are distributed to the structures of the face, neck, and upper extremities.

Of the *dorsal nerves* there are twelve pairs, which are distributed to muscles and integument of the back, the intercostal and pectoral muscles, mammary glands and muscles, and integument in front of the chest and abdomen.

There are five pairs of *lumbar nerves.* They supply the adjacent muscles and integument, the pelvic organs, and the lower extremities.

To what parts are the eighth pair of nerves distributed? Cervical nerves? Dorsal nerves? Lumbar nerves?

The *sacral nerves* comprise six pairs, which are distributed to the parts in the immediate vicinity.

The four upper sacral nerves give off branches which unite in forming a triangular body termed the *sacral plexus*, from

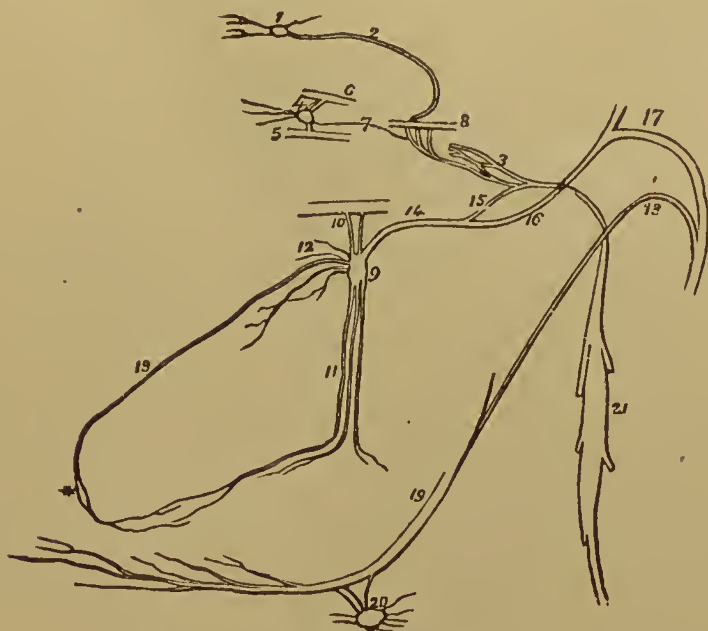

Fig. 181.—Cranial Ganglia.

Fig. 181 is a representation of cranial ganglia of the organic system. 1. Ganglion of Ribes. 2. A filament by which it communicates with the carotid plexus (3). 4. Ciliary or lenticular ganglion, giving off ciliary branches to the globe of the eye. 5. Part of the inferior division of the third nerve, receiving a short, thick branch, (the short root) from the ganglion. 6. Part of the nasal nerve, receiving a longer branch (the long root) from the ganglion. 7. A slender filament (the sympathetic root), sent directly backward from the ganglion of the carotid plexus. 8. Part of the sixth nerve in the cavernous sinus, receiving two branches from the carotid plexus. 9. Meckel's ganglion (spheno-palatine). 10. Its ascending branches, communicating with the superior maxillary nerve. 11. Its descending, or palatine branches. 12. Its internal branches, spheno-palatine, or nasal. 13. The naso-palatine branch, one of the nasal branches. 14. Posterior branch of the ganglion, the Vidian nerve. 15. Its carotid branch communicating with the carotid plexus. 16. Its petrosal branch, joining the intumescentia gangliformis of the facial nerve. 17. Facial nerve. 18. Corda tympani, which descends to join the gustatory. 19. Gustatory nerve. 20. Submaxillary ganglion, receiving the corda tympani and other filaments from the gustatory. 21. Superior cervicle ganglion of the sympathetic.

What is the distribution of the sacral nerves? How is the sacral plexus formed?

which branches are distributed to the genital organs and parts adjacent, and to the lower extremities.

Fig. 182.—Ganglionic System.

THE ORGANIC NERVES

The *organic nervous system* has the same relation to the vital organism that

In Fig. 182 is presented a view of the organic or sympathetic system. A A A A. Semilunar ganglion and solar plexus. B. Small splanchnic nerve. C. Great splanchnic nerve. D D D. Thoracic ganglion. E. Internal branches. F. External branches. G. Right coronary plexus. H. Left coronary plexus. I. Inferior cervical ganglion. J. Inferior twigs. K. External threads. L. Internal twigs. M. Anterior threads. N. Middle cervical ganglion. O. Interior twigs. P. External twigs. Q. Superior cervical ganglion. R. Superior branches. S. Inferior branch. T. External branches. U. Submaxillary gland. V. Vidian nerve. W. Naso-palatine branch. X. Spheno-palatine ganglion. Y. Ophthalmic ganglion. Z. Auditory nerve. 1. Renal plexuses. 2. Lumbar ganglion. 3. Internal branches. 4. External branches. 5. Aortic plexus.

the brain has to the mental. It presides over the development, growth, and

replenishment of the bodily structures. It is sometimes termed the *ganglionic* nervous system, because of the numerous ganglia of which it is largely constituted. It was formerly termed the *sympathetic* system, on a mistaken theory of its functions.

The organic nerves consist of a series of ganglia extending along both sides of the vertebral column; from these ganglia branches are distributed to all of the internal organs, communicating also with all the other nerves of the body.

The branches of distribution accompany the arteries, and form communications around them termed *plexuses.* These are named after the arteries, as mesenteric, hepatic, splenic, etc.

One of the most important ganglions of the organic nervous system, and which may be regarded as the central point of the system, is the *semi-lunar ganglion*, situated near the stomach, as seen in the cut (Fig. 182). It consists of an aggregation of smaller ganglia with intervening spaces; around it is a gangliform circle termed the *solar plexus.* The semi-lunar ganglion and solar plexus may be regarded as the presiding centre of the whole nutritive apparatus, and is doubtless the starting-point in the development of all living organisms.

What is the relation of the organic nerves to vitality? Over what does the organic nervous system preside? Why is the organic nervous system termed ganglionic? Of what do organic nerves consist?

CHAPTER XV.

MICROSCOPICAL ANATOMY.

VITALITY AND CHEMISTRY.

Dissections have enabled the anatomist to ascertain the various parts or organs of which the organization, as a whole, is composed; to determine the various structures of which the organs are composed, and to trace out the different tissues which form the structures. But the *elements* of the tissues are too fine for mechanical manipulations, too minute for unaided vision. What is known concerning them has been revealed by the microscope, and mostly within the present century. It is unfortunate, however, for microscopical researches, that physiologists and chemists do not make the line of demarkation clear between their respective sciences, as it is in nature. There is no more chemistry in the living organism than there is vitality in a block of granite. Much is said of "organic chemistry," "histo-chemistry," "zoochemistry," etc., as though the changes in living structures were analogous to those which occur in dead matter. They are very different. They are *transformations*, instead of the mere combinations and separations of elements.

Chemical analysis can never determine the constituents of the living organ, structure, tissue, cell, or germ; it can only ascertain what substances are left after the process of analysis has been performed. It takes no cognizance of that molecular arrangement which is the essential condition of life; and, moreover, chemical analysis can not commence until this molecular arrangement is destroyed—until death has taken place.

When a chemical substance is analyzed, a salt, for example, its ingredients can not only be ascertained, but they can be recombined and the substance reproduced. Chemical analysis may

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What is the distinction between vital and chemical actions? What does chemical analysis prove?

be proved by synthesis. Nothing of this kind happens in living structures. The food which nourishes the tissues is not combined with them, but transformed into them; nor are the tissues decomposed into their original elements, but transformed into excretions. Neither food, tissues, nor excretions can be reproduced by chemical art when once used or produced in a living organism. A multitude of errors in our standard works on chemistry and physiology will be corrected when this principle is universally understood and accepted.

It is true that the difference between organic and inorganic matter may consist simply in molecular arrangement, so far as we can discover by our present methods of investigation. But the principle, force, or element of life is something very different. Spontaneous generation has not yet been proved, nor has any rational theory yet been offered to account for mind—thinking and feeling—resulting from any combination or molecular arrangement of inorganic matter. No living organism, and, indeed, no organic matter, has yet been traced to anything but a prior living organism. All living structures are developed from cells, and are, perhaps, an aggregation of cells; and all cells are developed from an albuminous substance termed protoplasm. But cells, protoplasm, and albumen are produced only by the vital processes. Nothing but a living organism can produce either.

Chemistry claims to be constructive. This is true only in relation to dead matter. In relation to living matter it is purely destructive. The chemist can, indeed, make very good imitations of protoplasm, cells, and various organic products. He can imitate them so closely that neither analysis nor the microscope can detect any difference between them and the products of vitality. Yet they are as different as life and death. The vital protoplasm will produce cells, and these will form tissues, structures, and organs. But the chemical article will do neither. It will not grow nor reproduce itself.

The fundamental characteristics of organic matter are,

1. Nutrition.
2. Development, or Differentiation.

In what sense is chemistry constructive? What are the fundamental characteristics of organic matter?

3. Reproduction.

Nothing having the least analogy to either occurs in the inorganic world. And although the starting-point of all the vital processes is *in* the primordial cell, we are not yet able to say *what* the principle of life is. We can, however, demonstrate the fact that it is neither chemical nor mechanical.

THE CELL.

As all parts of the body are originally derived from the cell, this must be regarded as the primordial structural element. The cell is therefore a living thing, and a physiological unit. But the cell does not mean the smallest particle of a living organism which can be recognized by the aid of the microscope, and which is termed granule, vesicle, or crystal.

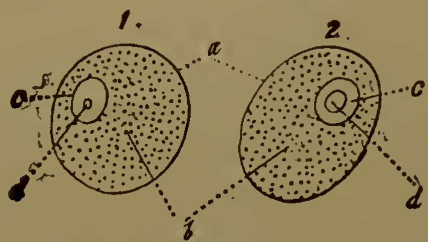

FIG. 183.—STRUCTURE OF THE CELL.

In Fig. 183 are shown the structural arrangements of two cells, one round and the other oval in form. *a a*, border of the cell; *b b*. cell body; *c c*, nuclei, with nucleoli, *d d*.

The cell consists essentially of a soft mass, enclosing a peculiar structure. The soft substance is termed the *cell-body*, the central structure within it the *nucleus*, and the minute particle within the nucleus, the *nucleolus*. In addition to these parts of a cell, there is sometimes a hardened stratum surrounding the soft substance, termed the *cell-membrane*. The cell-membrane was formerly regarded as an essential part of the cell, but later observations show that it may be entirely absent without affecting appreciably the physiological properties of the cell.

But, although these *anatomical* distinctions of the cell are

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From what are living organisms derived? What are the essential parts of the cell?

easily understood, its physiological properties introduce us into the world of mysteries. It possesses the power to change other matters into its own substance without being changed by them; and this is *vital transformation* as distinguished from chemical and mechanical actions. The cell absorbs, assimilates, and excretes—processes unknown to non-living matter; and in virtue of these processes, it develops, grows, multiplies, differentiates, resulting in the production of an organism of tissues and structures and organs, each performing a distinct function. Because of these physiological properties the cell has been termed an *elementary organism.*

The ovum of the higher animals and doubtless the ova of all animals, from which all animals originate, as vegetables do from seeds, possess the intrinsic nature of the cell; and there are microscopic animals whose whole organization consists only of a single cell, and whose "whole existence is included within the narrow circle of cell-activity."

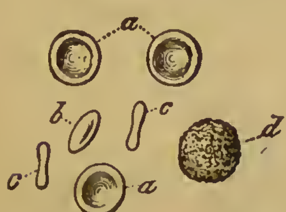

Fig. 184.—Cells of Human Blood.

In the process of development, cells assume very different shapes, the first divisions of which are the *flattened* and *tall narrow cell*, resulting from compression and flattening in opposite directions, as seen in Fig. 184, which represents the diskoid cells of the human blood, *a a a.* At *b* is a half side view; *d* represents a colorless corpuscle.

The primordial cell-substance is commonly known by the term *protoplasm;* but is termed by some authors, *bioplasm*, *cystoplasm*, and *sarcode.* "Protoplasm consists" (says Frey, in his "Histology and Histo-chemistry of Man," from which some of these illustrations are copied,) "of an extremely unstable albuminous compound, insoluble in water, but which becomes gelatinous (or in some instances shrinks) on imbibition of the latter; it coagulates further at a low temperature and at death, so that only by the most careful manipulation can it be examined in a normal condition under the microscope."

In Fig. 185 is a representation of different kinds of cells with

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How is vital transformation distinguished from chemical action? By what terms is the primordial cell-substance known?

nuclei and protoplasm. From *a* to *d* are seen elements of the cell with a medium quantity of protoplasm, and at *e* with a large proportion; *f* and *g* represent cells with a very small amount of protoplasm. A cell can never be produced from a nucleus which has lost its protoplasm.

Fig. 185.
Cells with Protoplasm.

It is an interesting physiological fact,—and one that should guard us against taking poisons or foreign substances into the system, whether mixed with food or drink, or in any other manner,—that foreign matters may penetrate the cells from without, as shown in Fig. 186.

In the cut *a* represents a lymph corpuscle with granules of carmine imbedded in it; *b*, another of the same, with included blood-cells and fragments of the latter; *c*, a heptic cell, containing fat globules and granules of biliary figments; *d*, a cell with fat globules and distinct membrane; *e*, another, with granules of melanin.

VITAL PHENOMENA OF CELLS.

The vital processes of cell life are termed *vegetative* because they are common to plants and animals—to all living organisms. They are *absorption*, *transformation*, *excretion*, *growth*, and *proliferation*. The living cells also possess the vital property of

Fig. 186.—Cells with Foreign Matters.

contractibility which, in the higher animal organism, is only manifested by the muscular tissue. The distinguishing pro-

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Do poisons penetrate the cells from without? What are the vital phenomena of cells?

perty of the animal kingdom is, therefore, the nervous tissue, whose functions are *thinking* and *feeling*. All other vital functions belong equally to the vegetable kingdom.

The white corpuscles of the blood, the corpuscles of lymph, pus, mucus, and those of the secretions, seem to be living cells, and resemble, microscopically, those organisms (amœbe) which are so simple and transparent as to be termed structureless. Nevertheless, these organisms have the power to move from place to place, to project organs or parts for special purposes, to take into their substance nutritive material, to assimilate food and thereby produce "formed-material," and eject the debris or effete matters. Indeed they perform all the vital processes, with the exception of those which pertain to a nervous system.

Fig. 187 represents a group of lymph-cells as affected by various states or degrees of contractility. They are taken from

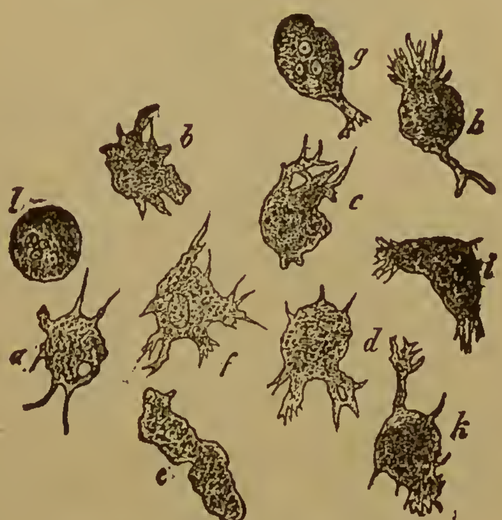

Fig. 187.—Contractile Cells.

the aqueous humor of an inflamed eye of a frog, and are hence more irregular and jagged than in the normal condition.

In Fig. 188 are shown the more symmetrical appearance of the white corpuscles of the human blood when their vital property of contractility is exercised. From 1 to 10 is represented

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What vital properties distinguish the animal from the vegetable kingdom? How do the white corpuscles resemble amœbe

by a series of changes which have been observed within a period of forty minutes duration, ultimating in the formation of the stellate cell, b.

The manner in which cells may be arranged so as to form tissues, structures, and finally organs, is illustrated in Fig. 189, which is a representation of the living connective tissue from the frog's leg.

The power of cells, corpuscles, amœboids, etc., to pervade the

FIG. 188.—WHITE CONTRACTILE BLOOD-CORPUSCLES.

tissues, structures, and organs of the body, is explained by their ability to adapt their shape to the channels they traverse. Says Frey, "This wandering of amœboid cells through the interstices of living parts was discovered years ago by *Recklinghausen*. The readiest mode of studying the phenomenon for ourselves is by taking a drop of some fluid containing cells from the body. In the tissues of the system the cells wander on with a continual change of shape through fine, narrow interstices (usually compressed somewhat into elongated figures), and traverse thus in a short space of time comparatively large distances."

Dr. Lionel S. Beale, in his work, "How to Work with the Microscope," says: "Hitherto many of the movements occurring in living things have been referred to the property of *contractility*, and, strange to say, the very authorities who never lose an opportunity of condemning those who attribute any changes in things living to the influence of a peculiar force or

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How is the power of cells, etc., to pervade the structures explained? How can the fact be ascertained?

power—*vitality*—consider that movements are sufficiently explained and accounted for if they are attributed to this mystical property of *contractility*. They do not attempt to define what they mean by the word, nor do they show in what this supposed property resembles or differs from other properties of matter. They do not state whether it is peculiar to the living state or is manifested after life has ceased.

"Many facts have convinced me that there is an absolute difference between *living* and *non-living* matter, and I maintain

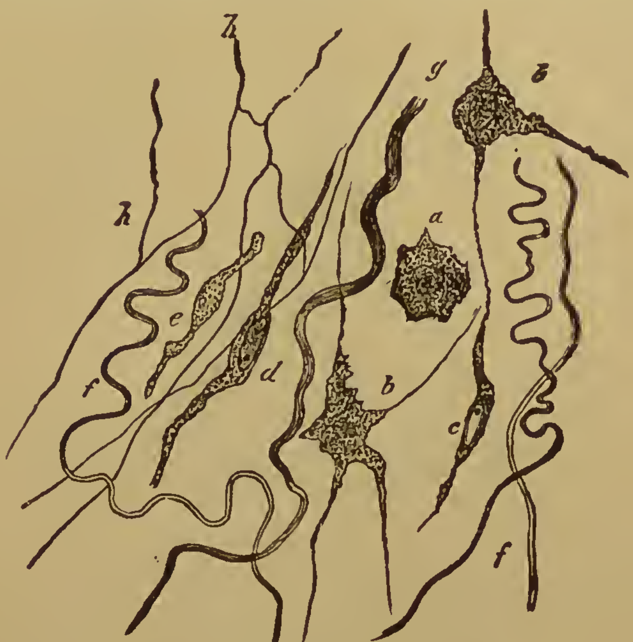

FIG. 189.—CONNECTIVE TISSUE.

that the assertion that the *non-living* passes by gradations into the living is not justified in the present state of scientific knowledge.

"Some of the most remarkable phenomena which distinguish living from *non-living* matter may now be observed under the microscope with the aid of the highest powers. There is no department of natural knowledge in which a greater advance is to be noticed than this, and the facts which have been recently discovered enable us to draw a sharp and well-defined line

Is it proved that non-living matter passes by gradations into living? How can the phenomena which distinguish them be best observed?

between living things and the various forms of non-living matter, be it of simple or complex composition. If as investigation still further advances, the facts already known are confirmed, and the conclusions arrived at from recent researches, supported by new observations and experiments, the operation of some agency, force or power, in living matter, distinct from every kind of physical force operating in non-living matter must be admitted, and the views at this time most popular will have to be modified in most important particulars."

It was very natural for physiologists, after exhausting all the resources furnished by the higher animals and larger plants in

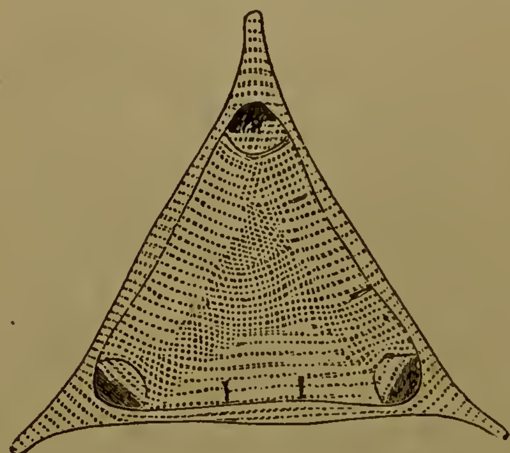

FIG. 190.—SHELL OF A DIATOM.

the pursuit of the knowledge of the origin or starting-point of life, to seek it in the lowest and minutest organisms with the aid of the microscope. But the problems of life seem to be as mysterious and complicated in the minute as in the massive organisms. The little *diatom*, millions of which can exist within the space of a cubic inch, possesses tissues, structures, and organs, if not as elaborate, as wonderful as those of the elephant; and the *yeast plant*, which develops in decaying albuminous substances by the process known as *fermentation*, has a structure as marvelous as the largest tree.

The representation of the shell of a rare diatom (Fig. 190) shows a structure quite as admirable as does the skin or bark of any animal or plant.

How is the yeast plant developed? What is the nature of the yeast plant? To what is the life-element invariably traced?

Within a few years chemists and physiologists have given much attention to the study of the nature of fermentation, justly regarding the putrefaction of albuminous matters and the production of the living organisms now known as the yeast plant, or fungus (it was formerly regarded as an animal organism), as affording important data in relation to the origin of life. But here, as everywhere, the mode or manner in which the non-living becomes living eludes all research; and as is the case with mold, mildew, and all other microscopic fungi, the life-element is invariably traced to some prior living thing.

FIG. 191.—THE YEAST PLANT IN VARIOUS STAGES.

In Fig. 191 the yeast fungus is represented in various stages of development.

DEATH.

Although few persons die naturally, death is as natural as life. The primordial germ is a gelatinous fluid. In mature life the structures are more solidified. In old age the solids are so disproportioned to the fluids that the nutritive processes can no longer be carried on, and death ensues. All through existence, from the inception of life to the latest breath, the process of solidification is unremitting. But it may be greatly hastened by improper ingesta and abnormal influences. Hard water, foreign substances of all kinds, and stimulants which waste the fluids, are predisposing causes of diseases, and causes of premature death. Diseases of all kinds, though necessary vital struggles against morbific causes, occasion waste of vitality and abbreviate the period of life.

In a life, according to the laws of life, death is not preceded by sickness nor attended with pain. It is but a sleep that knows no waking.

What is the rationale of natural death? What circumstances hasten death? Is natural death painful?

CHAPTER XVI.

HYGIENE.

CLEANLINESS.

THAT "cleanliness, which is next to godliness," implies obedience to every law of the vital organism. The common causes of disease are poisons introduced from without, through the stomach, lungs, or skin, and poisons ingeneration in consequence of retained effete matters. Cleanliness, therefore, demands as much attention to the ingesta as to the surface. Unless this be attended to, no amount of washing or bathing of the skin will prevent foul blood, morbid secretions, and general impurity. Many persons are fastidiously neat with regard to their hands, faces, dress, and the furniture of their apartments, yet strangely reckless of what they swallow, inhale, or absorb. Pure blood, without which no one can be clean within, whatever may be the external condition, cannot be maintained unless all the excretory organs—the skin, lungs, liver, bowels, and kidneys—are kept free and unobstructed. And this cannot be done without the proper use of all hygienic agencies, and the misuse or abuse of nothing.

In all places where offal or garbage is allowed to accumulate sickness prevails; and if the accumulation be great or prolonged pestilences occur. There is little doubt that all contagious diseases — small-pox, measles, whooping-cough, mumps, etc.—would soon disappear were all the people cleanly in their persons and surroundings. Stagnant water is known to be as prolific a source of disease as are atmospheric impurities. Sinks, cess-pools, drain-pipes, etc., should never be allowed to become offensive to the senses; and all excrement should at once be removed from dwellings, or disinfected with earth or chemicals. The gases arising from rotting and decaying animal and vege-

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What are the common causes of impure blood? What are the special causes of contagious diseases?

table matters are the causes of some of the most malignant fevers known.

In country places all offal and garbage should be promptly removed to the compost heap, which should be so distant from the dwelling as to be inoffensive; and in cities it should be burned by the cook, instead of being deposited in the ash-box to infect the atmosphere. Garbage thrown into the gutters and ash-boxes has much to do in rendering tenement-houses pestilential.

FOOD.

Without discussing the vegetarian theory, we may accept the conclusion of eminent naturalists that the organization of the human being indicates that his natural dietetic character is frugivorous; and as all intelligent physiologists agree that all nutrient material for man and animals is produced by the vegetable kingdom in the processes of development and growth, it seems to follow that vegetable productions, when perfect of their kind and properly prepared, constitute the best food for man. Plants feed on inorganic matters. They compound, or rather transform, them into certain proximate elements—fibrin, albumen, casein, gum, sugar, starch, lignin, etc. But these proximate elements are not properly food. They are merely *alimentary principles*, not *aliments*. It is the organic arrangement (not chemical combination) of these proximate elements into a whole that constitutes true food — grains, fruits, and vegetables.

Certain "carnivorous plants" which have lately been discovered, and which entrap and destroy flies and other insects, are thought by some to prove that some plants, at least, can feed on organic as well as inorganic matter. But the seeming exception may be delusive; for, as plants absorb gases from the atmosphere through their leaves, and earthy matters in solution through their roots, it is quite probable that the insects which some plants seem to devour are reduced to their inorganic constituents before being *eaten*.

But if animal food, in part, is to be preferred or permitted, it is certain, if not self-evident, that the flesh of the herbivora is

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How is food produced? What are alimentary principles? What are aliments proper?

the more wholesome kind; and the experience of four thousand years has not taught civilized men any better rules for discriminating between the more and less wholesome kinds of animal food than are found in the Mosaic code.

All writers on dietetics agree that simplicity in food, both in respect to the kinds taken at a meal and the mode of preparation, is essential to good health; and for these reasons nearly all the recipes found in our fashionable cook-books can be regarded as little else than dietetic abominations.

Highly-seasoned dishes are condemned by universal experience. All condiments are foreign substances, and in no sense nutritious; hence, an infallible rule to regulate their employment is, the less the better. Their excessive use is a common case of dyspepsia and its manifold complications. They are chiefly employed to improve the relish of food or provoke appetite, and by many physicians and physiologists are supposed to promote digestion. But nature teaches that the normal actions and secretions of the living structures are the only promoters of digestion, and that all proper food is not only palatable, but delicious, to the pure and unperverted instinct. Many persons, by disusing all condiments for a short time, have acquired such a keen appreciation of the gustatory properties of food as to relish all kinds much better without salt, vinegar, pepper, mustard, or spices, than with. Butter, cheese, sugar, starch, etc., can only be regarded as products of organic matter, or alimentary principles, and not in any sense aliments or foods proper. They are conducive to various diseases of indigestion, and their excessive use is doubtless one of the principal causes of that morbid condition of the system known as "biliousness," while they also predispose to scrofulous and erysipelatous affections.

Probably the most pernicious custom in relation to the dietetic habits of the more enlightened nations, consists in the use of fine or superfine flour, instead of meal, in the manufacture of bread-food.

The bran of wheat and other grains contains nutritive elements which are essential to perfect nutrition, and which do not exist in the finer portions within; hence, when more or less of the

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What are the Hygienic rules in relation to food? What of high-seasoned dishes? What of superfine flour?

bran is separated the value of the grain as food is correspondingly deteriorated. Whenever bread made of bolted meal is a principal article of diet, constipation and its innumerable train of secondary ailments are the inevitable results.

The rejection of the bran is a great loss in a commercial, as well as in a sanitary sense. As grains, like all other foods when not preserved by ice or the exclusion of atmospheric air, constantly deteriorate from the moment that the organic arrangement of their molecules is destroyed, the actual nutritive value of the finest flour, as we find it in market, cannot be one-half that of freshly-ground and unbolted meal; and when we find it in the shape of baker's bread, still further deteriorated by means of fermentation, and always mixed with salt, and often adulterated with alum, ammonia, bar-soap, or other substances, its value as food is still further diminished. The loss to the civilized nations in this item alone, amounts to hundreds of millions of dollars annually—more than enough to feed all the paupers on the earth. Bread made of unbolted meal and pure water ensures proper mastication, and thus preserves the teeth; and good teeth are essential to the integrity of the whole digestive apparatus.

Bread.—Perfect bread may be made of wheat-meal, corn-meal, rye-meal, or oat-meal, or of admixtures of any of them in proportions to suit the taste or fancy, and pure water. If cold water is used, the dough should be thoroughly kneaded to incorporate as much atmospheric air as possible, in order to render the bread light and crisp; and the colder the water is the more tender the bread will be. If hot water is used less kneading is required, and the bread will be softer and more moist. Excellent fruit-bread may be made by mixing more or less of stoned raisins, stoned dates, English currants, or stewed figs, or all of them, with the dough. The dough should be rolled out on the bread-board of any thickness desired, covered with the fruit, turned over to enclose the fruit, rolled tightly into a loaf and baked in a hot oven. When a richer article is desired, cocoanut may be grated over the fruit. All bread made of meal and water should be baked in a quick oven. If

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Why should grain for cooking purposes always be freshly ground? How can perfectly wholesome bread be made?

covered with a cloth, when taken from the oven, and placed in a stone crock or other covered dish, the crust of the bread will absorb the moisture and become soft. Those who have good teeth, however, generally prefer the harder crust.

Sweet potatoes, stewed pumpkin, apples, and peaches may be used, if any prefer their flavor to that of the fruits above-mentioned.

MUSHES.—Wholesome mushes may be made of crushed wheat, oatmeal, hominy, corn grits, and corn-meal, or of the whole grains of wheat or rye. Mushes of all kinds should be stirred very little after the material *sets*, or stops sinking to the bottom. The water should boil when the meal is stirred in, and kept boiling till the meal ceases sinking; when the dish should be covered, and cooked slowly until done. When fruit is added it should be cooked in a separate dish, and mixed with the mush just before dishing.

PIES.—Healthful and delicious pastry can be made of wheat-meal dough and any kind of good fruit, pumpkins, or squashes. To make the crust, roll out the dough very thin, sprinkle a little meal over the pie-plate, and cover with the fruit. An upper crust may be added or not, as preferred. To render the upper crust soft and tender, the pies should be covered with a cloth as soon as removed from the oven. Dates, figs, or raisins may be used to sweeten when the other fruits are too sour.

PUDDINGS.—Puddings are substantially-baked mushes. In making them such materials should be selected as will, when cooked, present a light, spongy mass. Good puddings may be made of corn-meal mush, rice, bread, crackers, Graham flour, mixed with any good fruit into a mush, and baking in a hot oven.

SAUCES.—Wholesome and palatable sauces for puddings or mushes, may be made of dates, figs, raisins, grapes, apples, peaches, currants, etc., mixed to suit the taste, flavored, if desired, with grated cocoanut or lemon juice, or both, with the addition of sufficient Graham flour to give the proper consistency. Dates, with almost any good canned fruit, make an excellent sauce, applicable to all kinds of puddings.

How can wholesome mushes be made? Pies, Puddings? Sauces?

SOUPS.—Good soups can be made of one or more vegetables, boiled very soft, and diffused through a large proportion of water. Potatoes, peas, and beans, are the favorite articles; carrots, parsnips, turnips, and cabbage, are more or less employed by those who have given special attention to hygienic cookery. Rice, spinach, or tomatoes, are sometimes added.

Broths are merely thin soups; porridges are thin mushes, and gruels are thin porridges. The latter is usually made of corn-meal, or wheat-meal, and its use is mostly limited to invalids affected with inflammatory and febrile diseases.

VEGETABLES.—The only wholesome manner of cooking vegetables of all kinds is by boiling, or baking, or steaming; and the secret of good cooking in boiling consists in using as little water as possible, putting the vegetables into the water when it is at the boiling point, and removing them as soon as done. In baking, the vegetables should not be put into the oven until it is hot, and should be removed and served as soon as sufficiently cooked.

Among those vegetables which are edible and wholesome at all stages of growth are peas, beans, corn (and, probably, all grains), beets, asparagus, spinach, and cucumbers. Of course it is wasteful, in a commercial sense, to use any vegetable or fruit until fully grown and matured; but unless rendered unwholesome by improper admixtures or seasonings, the above articles are as innocuous as delicious to healthy digestive organs and normal appetences.

FRUITS.—No cooking or seasoning can improve the flavor or wholesomeness of the sweet and sub-acid fruits, when of good quality and thoroughly ripened. Green and very acid fruits may be baked, steamed, or stewed, and seasoned to suit the taste with some sweet fruit—as dates, raisins, figs, sweet apples, whortleberries, etc. Cranberries, currants, gooseberries, quinces, rhubarb, and the crab-apple, comprise the list of fruits in our markets which require the admixture of sweeter fruits to season them with.

DRINK.

From the multitude of beverages in common use, most of

What is the rule for making wholesome soups? How should vegetables be cooked? Fruits?

which are commended by physicians and physiologists, "the natural dietetic character of man," so far as drink is concerned, might seem to be a very complicated problem. But if we study the Book of Nature instead of the books of men, the subject becomes very simple. Nature has provided no drink for man, animals, or plants, except water, and the purer it is the better. The "virtue" of all other beverages depends on the water they contain, while the foreign ingredients, of whatever name or nature, constitute their *vices*. The uses of water in living organism, are to convey nutrient materials to, and waste matters from, all parts of the bodily structure, and to regulate temperature. These purposes cannot be better subserved by any admixtures of drugs or other impurities. All saline or earthy matters, and all foreign ingredients of every kind, render the water less solvent, and to that extent less capable of holding the nutrient or waste matters in solution and transporting them to or from the body.

Most of the thirst which calls for so much water-drinking, and all of the thirst which demands artificial beverages, is abnormal, and is occasioned by improper aliments and seasonings. Those who use a pure dietary and little or no seasonings, require comparatively very little water; while if their exercises are moderate and their other habits hygienic, they can do very well without drinking at all.

The amount of money which is expended for intoxicating and other beverages by the civilized nations, is enormous. It is within the bounds of certainty to say that the people of the United States annually waste in this manner more than one thousand millions of dollars. But if the waste of vitality could be reckoned in dollars and cents, the amount of loss would be more than doubled.

BATHING.

Bathing the whole surface of the body occasionally with warm, tepid, or cool water, is very useful to most persons; but bathing, in a general sense, is to be regarded as a therapeutic or remedial rather than a hygienic process. If our habits were in all respects normal, the skin would perform its depurating func-

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What beverages has nature provided? What are the usual causes of excessive thirst?

tion without bathing, as well as the mucous membrane within can do its duty without washing. But the improper ingesta, and the foreign substances constantly taken into the system through the media of the digestive organs, lungs, and skin, necessitate more or less bathing, to enable the system to rid itself of some of them through the cutaneous emunctory. The rules for bathing, therefore, are as various as the habits of people are different.

So far, however, as bathing may be useful, when not employed as a remedial agent in the treatment of disease, it is very easily managed. A quart or two of water and two or three towels, are all the materials necessary, although bathing-tubs, ponds, o streams may be convenient. It is a great mistake to suppose that there is any special virtue in salt water, mineral water, or medicated or impure waters of any kind, for either bathing or drinking purposes. Whenever surf-bathing or swimming is more useful than ablutions, it is because of the exercise which accompanies it. And it is also a mistake to suppose that any amount of bathing at the sea-side or springs, during a few days or few weeks, can so purify and invigorate the skin as to keep it in a healthy condition the remainder of the year. A tepid ablution in one's private room at home the year round, is better than any amount of bathing that can be enjoyed or endured during one month or six months of the year.

Persons should never bathe soon after eating, nor when the body is much fatigued; the room or place should be of an agreeable temperature, and the water should not be so cold as to occasion permanent chilliness, nor should the bathing be so prolonged as to induce a sense of languor or weariness.

VENTILATION.

Pure air is as essential to good health as are pure food and pure water. As atmospheric air is normally composed of nearly four parts of nitrogen to one of oxygen, with an admixture of three to six parts in one thousand of carbonic acid gas, and a small proportion of watery vapor, all deviations from this standard, and all factitious gases, particles, or organic germs,

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What is the necessity for bathing? What rules to be observed?

are sources of imperfect respiration, impure blood, and vital waste.

There are many impurities which sometimes so accumulate in the atmosphere as to become causes of pestilence and death, but which no chemical or microscopical examinations can detect. The nature of the malaria which occasions periodical fevers, the *fomites* which causes yellow fever, the miasms of the gutters and tenement-houses which cause typhoid fevers, and the emanations from offal and excreta which constitute the essential causes of croup, diphtheria, small-pox, measles, as well as the virus and venoms of animal origin, have thus far eluded all attempts at chemical and microscopical analysis. But for all practical purposes it is enough to know that strict cleanliness and ample ventilation are our only preventive resources.

A constant ingoing stream of oxygen is required to combine with the dead particles of the worn-out tissues and facilitate their removal, while a constant out-going stream of carbonic acid gas is exhaled from the lungs. If, therefore, the room be not properly ventilated, the supply of oxygen is deficient, while the exhaled carbonic acid gas accumulates, rendering the air irrespirable, and, in extreme cases, inducing suffocation. The carbon that is expired into the atmosphere is absorbed, fed upon, by the vegetable kingdom, thus purifying the atmosphere of its presence.

Says Professor Youmans ("New Chemistry"): "The relations of the atmosphere to living beings, the stability of its composition, and the wonderful forces that are displayed within it, have been but lately enfolded by science, and are full of surpassing interest. The vegetable world is derived from the air; it consists of condensed gases that have been reduced from the atmosphere to the solid form by solar agency. On the other hand, animals, which derive all the materials of their structure from plants, destroy these substances, while living, by respiration, and when dead, by putrefaction, thus returning them again in the gaseous form to the air from whence they came. In respect to air, the offices of plants and animals antagonize. What the

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What are the atmospheric causes of impure blood? What is the effect of deficient ventilation?

former derives from the air, the latter restores to it, thus maintaining its equilibrium and permanence."

Notwithstanding the importance of our abundant supply of pure air is well understood by physiologists, very little attention is paid to ventilation in places where large masses congregate. Very few halls, churches, school-houses, theatres, ocean steamers, and railroad cars, are properly ventilated; and the same may be said of most sleeping apartments.

The poisonous atmosphere that nearly all of the children of the public-schools in our cities are compelled to breathe, is strikingly and startingly illustrated in a recent report on the healthfulness of the school-houses in Philadelphia, which are certainly no worse than the average. The Philadelphia *Ledger* for June 24, 1875, says:

"At the meeting of the American Public Health Association in this city in November last, the subject of School Hygiene was discussed at length. Acting upon the suggestions then made by Dr. D. F. Lincoln, the Philadelphia Social Science Association prepared a series of questions on the health of our public schools, addressed to the teachers, and another to physicians, inviting their aid in investigating the subject. The Board of Education of this city adopted them as the basis of circulars addressed to Principals of Grammar Schools and Directors of our Public Schools, and the answers were received, and, with the aid of the Social Science Association, arranged and digested. The results were presented in tabulated form at the recent meeting of the American Social Science Association in Detroit, Michigan, and Dr. Lincoln made them the subject of an address, which was followed by an interesting discussion. These examinations of the condition of our public schools as to the health of the pupils are almost the first, certainly the first with any system, ever carried out in the United States, and the printed broad sheet in which the answers are digested contains a great deal of information concerning the sanitary condition of our public schools. There are nearly four hundred separate reports or answers, each making more or less full replies to the seventeen questions addressed to teachers, and thirteen to the doc-

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Why are tenement houses pestilential? Why are most school-houses injurious to health?

tors who assisted in the investigation. A careful revision of the summaries made by Dr. Lincoln gave, as he reported, the following results of the examination of our Philadelphia school-houses: That, with the exception of one new building, not a single school-house had effective ventilation, the only available method of getting fresh air in the rooms being by open doors and windows — practically often impossible by reason of bad weather, or the noise and dust of crowded city neighborhoods; and finally, that much of the complaints common to teachers and scholars was due to poor ventilation, improper selection of desks, crowding studies, and ill-arranged school sessions. An analysis of the condition of the air in twenty of our Philadelphia schools will be published in book form. This shows the extent to which the air is contaminated; in its pure condition, there are from three to four parts of carbonic acid to every 10,000; in the school-rooms, it ranged from six to twenty-one, and averaged thirteen and a half.

TEMPERATURE.

Human health may be enjoyed in all latitudes, from the equator to the regions of perpetual snow. But it is only in the temperate zone that human beings attain their highest moral and intellectual development. In some places in inhabited parts of the torrid zone, the thermometer often rises to 130° Fahrenheit, while explorers in the Arctic regions sometimes live for months in a temperature ranging from 50° to 70° below zero. In New York the temperature has a range of about 100°, seldom rising above 100° Fahrenheit, or falling below 0. But the changes of temperature in this climate frequently amount to 40°, and sometimes to 50°, within twenty-four hours.

Sudden and extreme changes of weather are the exciting causes of many diseases; but they would be comparatively harmless did not the predisposition to disease exist as the consequence of our erroneous habits of living. "Catching cold," which is the starting-point of so many maladies, could never occasion more than a temporary inconvenience were not the

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What is the relation of temperature to health? What is the thermometrical range in New York?

system in some abnormal condition, and having some one or more of its depurating organs obstructed.

Undoubtedly, however, a mild climate and uniform temperature are more conducive to permanent health and longevity. But in this, as in all colder climates, artificial heat is a "necessary evil;" and the hygienic rule for warming all dwellings and apartments, is (after providing for ample ventilation) to keep the temperature as low as possible consistently with comfort. This will generally be a little below summer heat—from 60° to 65°; some allowance, however, must be made for the temperature one has previously been accustomed to, when changing from one locality to another, as a sudden rise or fall of the temperature 15° or 20°, would vary the point of comfort some 5° or 6°.

CLOTHING.

In a strictly hygienic sense, the only use of clothing is to protect the body against atmospheric vicissitudes. For this purpose it should be as equally distributed over the body as possible; nor should it be allowed to restrain in the least the motions of any muscles or organs of the body. The material may be properly regulated by the sense of comfort. The principal errors in the dress of men are misshapen boots and shoes, stiff "stove-pipe" hats, and heavy or tight cravats, or "chokers." With fashionable women the dress is, in a general sense, all wrong. It would be difficult to invent anything more destructive to health, more ruinous to comfort, more inconsistent with true taste and utility, or more degrading in all its moral consequences. Tight shoes and high-heeled gaiters distort the feet and render easy and graceful locomotion impossible; tight-lacing diminishes respiration, prevents due aeration of the blood, and thus directly cuts off the sources of vital energy; while heavy skirts supported on the hips occasion congestion, and frequently inflammation, and sometimes ulceration, of the pelvic and abdominal viscera.

Esthetic considerations do not belong to a work of this kind; but certainly all forms and articles of costume that violate every

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What is the hygienic rule for clothing? What are the common abuses of clothing?

law of life, cannot be consistent with any recognition of the beautiful, except that which is the outgrowth of a monstrous perversion of the sense of beauty.

LIGHT.

The scientific world now recognizes light to be a "mode of motion," and correlated with heat, electricity, magnetism, and attraction. The influence of sunlight is essential to the development and growth of all the higher organisms of plants and animals, and also of man; and, within certain limits, the more human beings are exposed to sunshine, the most perfect will be their health and the more firm and enduring their structures. All physiologists understand the importance of so constructing dwellings as to admit as much light as possible into all of the apartments, although the rule is often disregarded by architects. Persons who live in underground rooms which are not well lighted, or in any apartments which are constantly shaded, become frail, scrofulous, and cachectic.

Light, as well as air, is a powerful disinfectant, purifying the atmosphere of miasms which otherwise might be the cause of putrid fevers and contagious diseases. When the heat is excessive, the head should be protected from the direct rays of the sun, and with this precaution one can hardly have too much of the vitalizing influence of the sun. Vails and waterfalls are extremely injurious to health; the former induce weakness of the eyes, and the latter occasion congestion of the brain. Light and air should at all times during the day be allowed to circulate freely among the hairs of the head; hence, the ordinary method that ladies have of wearing the hair braided or twisted into an impervious mass on the top or back of the head, has a damaging effect on the brain, and through that organ on the whole system. Much of the headache so prevalent in fashionable society is attributable to this cause. Whether the hair be long or short, there can be no "sound *brain* in a sound body," unless it is worn loose and flowing.

SLEEP.

The hygienic rule for sleep is determined by an astronomical

With what is light correlated? What is the relation of sunlight to vitality?

law—the revolution of the earth on its axis; hence the vexed question, "How much sleep do human beings require?" is easily answered—all that can be had during the night. A person in health can never sleep too much; for when the object of sleep is accomplished he will awaken. Those who cannot sleep on retiring at the usual hour, or who dream during sleep, or who awake before sleep has had its "sweet restoring" influence, are in some sense invalids; hence, all the rules for remedying sleeplessness should have reference to the causes of mental disturbance. The following remarks copied from the "Hygienic Hand-Book," are in point:

"Invalids, generally, do not sleep enough. The importance of sound, quiet, and sufficient sleep cannot be too highly estimated, as may be inferred from the physiological fact that it is during sleep that the structures are repaired. The materials of nutrition are digested and elaborated during the day, but assimilation—the formation of tissue—only takes place during sleep, when the external senses are in repose. Literary persons require more sleep, other circumstances being equal, than those who pursue manual-labor occupations. If the brain is not duly replenished, early decay, dementation, or insanity will result. The rule for invalids is, to retire early, and remain as long in bed as they can sleep quietly. If their dietetic and other habits are correct, this plan will soon determine the amount of sleep which they require. Gross, indigestible, and stimulating food, heavy or late suppers, etc., necessitate a longer time in bed, for the reason that the sleep is less sound. And for the same reason, nervine and stimulating beverages, as tea and coffee, prevent sound, refreshing sleep, and thus wear out the brain and nervous system prematurely. Those who are inclined to be restless, vapory, or dreamy, during the night, should not take supper."

It is because assimilation is mainly effected during sleep, that infants, whose principal business is to grow, require so much more sleep than adults.

BEDS AND BEDDING.

Bed-clothing should be as light as possible consistently with

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What is the hygienic rule for sleep? What is the physiological necessity for sleep?

comfort, and mattresses as hard and level as they can be made with hair or sponge; corn-husks, straw, and various palms and grasses, make wholesome and comfortable beds. Feather-beds are being generally discarded as physiological knowledge increases; but in most hotels and boarding-houses, feather-pillows are still retained. They are certainly very pernicious. It is common in our first-class hotels—and the same is true of many private houses—to find a good, wholesome hair mattress, and all other parts of the bed and bedding unobjectionable, with the exception of the pillows. These are made so thick with feathers that it is impossible to rest the head on one of them without crooking the neck injuriously; and to make a bad matter worse, a thick feather bolster is placed under the pillows. One pillow of moderate size, without any bolster, is enough for health and comfort. For young children, and infants especially, the pillow should be very small and thin.

EXERCISE.

Health and vigor cannot be maintained without a due amount of exercise; and the hygienic rule consists in exercising all parts of the muscular system as equally as possible. It is possible, by means of special exercises, to develop some sets of muscles and some organs of the body to the detriment of others. Gymnastic exercises, so well adapted to sedentary persons, unless properly varied, are liable to invigorate some parts of the body at the expense of other parts. Says the "Hydropathic Encyclopædia": "People of all trades and occupations find those parts of the muscular system which are habitually the most exercised to be the most powerful. Thus farmers have the whole muscular system nearly equally developed; blacksmiths, carpenters, sailors, etc., have strong arms and chests; travelers, dancers, etc., are disproportionately developed in the lower extremities; shoemakers, tailors, etc., have a tolerable development of the arms and chest, but suffer in the lower extremities and abdomen; merchants, clerks, and others who pursue an easy, in-door occupation, have slender muscles generally; and

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What is the relation of exercise to health? What is the hygienic rule for exercise?

fessional men, whose exercise is more intellectual than bodily, exhibit large brains with slender muscles."

It happens, fortunately, that those vocations which are the most necessary for human existence, are most conducive to health and longevity; hence agricultural pursuits outrank all others in this respect. It is true that farmers and housewives do not, generally, in this country, by their health conditions, advertise their occupation favorably: but it is because many of them work intemperately, and nearly all of them are exceedingly unhygienic in their dietetic and other habits—more so, probably, than any other class of society. They have the means for the best health, but are the worst abusers of the means.

All exercise — labor or play — which occasions a degree of fatigue that is not readily recovered from on resting, is injurious, and all within that limit is useful. Violent exercise should never be taken immediately before nor after meals; nor should lunches or other "refreshment" ever be taken between meals, in view of performing some extraordinary feat or unusual labor. Severe diseases and sudden deaths have been the result of this error.

As substitutes for manual labor, walking, riding, rowing, quoits, croquet, ball, etc., are among the best out-door exercises; while dumb-bells, clubs, wands, the light gymnastics, calisthenics, lifting-machines, etc., with parlor-skating and dancing, afford an ample variety of in-door exercises from which to choose.

The hygienic rule applicable to all persons and to all kinds of exercises is to commence very moderately, and gradually increase them in length and vigor as the muscles which are specially called into action become accustomed to the motions. They should never be performed with sufficient violence to occasion distressing panting, or a painful throbbing or palpitation of the heart. To guard against these excesses, it is well to keep the mouth firmly closed while exercising, and discontinue or moderate the exercises whenever it becomes necessary to open the mouth.

With regard to the exercises of children, the following para-

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What conditions prohibit violent exercises? What special rule should be observed?

graph, copied from the "Hydropathic Encyclopædia," seems to cover the whole ground: "Our social organization is very defective in its provisions for the appropriate exercises of infants and young children. The cradle is a most unphysiological method of exercising a child to sleep; its primary object was to save the nurse trouble, but a child accustomed to be rocked to sleep will give the nurse more trouble in the end, than one accustomed to sleep without such assistance. The motion of the cradle, too, is injurious to the brain and nervous system. The modern 'baby-jumper' is a better contrivance, but even this can be advantageously superseded by giving the child 'the largest liberty' to exercise in its own way. Plenty of room, a smooth floor, and a plentiful supply of 'playthings' which are not dangerous — india-rubber balls, baskets, brooms, rattle-boxes, etc.—afford the opportunities which a child will always improve to the best possible advantage. Unfortunately, among the poorer classes of our cities, young children are kept in stupid inactivity simply because they have no room in which to stir; and this confinement renders them sickly, puny, peevish, and indolent."

REST.

Rest is as important a law of life as exercise. The divisions of time into day and night, constitute the basis of the physiological law for exercise and rest in all the habitable parts of the earth, so far as the mental organs are concerned; and the more nearly we conform our habits and occupations to this order of nature, the more prolonged will be our terrestrial sojourn. Rest during the day should have reference to our habits and occupations. Persons who are in perfect health are a law unto themselves in this respect. Their sensations will guide them correctly when and how to exercise. No healthy person can be indolent or lazy. Laziness implies disease, or some abnormal condition; for all normal exercises are pleasurable when the conditions are normal.

But, unfortunately, there are few perfectly healthy persons; hence erring reason must do the best it can for what unerring

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What relation has day and night to rest? Who are a law unto themselves? What does laziness indicate?

instinct would have done in an unperverted condition of the vital organism.

The vital functions of circulation, respiration, absorption, secretion, and excretion, seem to be restless and unremitting from the inception of life in the blending of the germ and sperm-cells, to death; but a closer examination shows that vital, as well as mental organs, have their periods of action and repose. The heart rests between each contraction, the lungs rest after each inspiration and expiration, and each organic cell rests between each act of assimilation, formation, or disintegration. The function of digestion rests several hours during each day of twenty-four hours, and those functions which pertain to reproduction have periods of rest extending through weeks and months.

PASSIONAL INFLUENCES.

Mental hygiene, which means the due exercise and rest of the mental powers, is not less important to health than is bodily or vital hygiene. Probably as many diseases are incurred, and as many lives ended prematurely, because of a misuse or abuse of the mental propensities, as by any other cause that can be named. The hygienic rule for the exercise of the passions is a very plain one, and consists simply in subordinating them all to use; they are to be employed or indulged only in relation to the legitimate purposes of life. In all ages philosophers and poets have understood and taught the important lesson that our passions, though admirable servants, are terrible masters. And it is an equally important and eminently practical truth, that the exercise of all the nobler emotions, the moral sentiments, and the intellectual faculties, are conducive to health, while the "baser passions" (the abnormal exercise of the propensities) are powerfully destructive to the vital energies. To understand the principle indicated, we have only to contrast the manner in which hope and fear, love and hatred, benevolence and anger, mirthfulness and grief, gratitude and envy, conscientiousness and remorse, energize or depress the whole being.

What is understood by mental hygiene? What is the hygienic rule for exercising the passions?

The ancient stoics, to obviate the evils resulting from passional abuses, sought to subdue the passions, and attain to a purely intellectual existence. But this was to ignore one-half of their nature, all of which was "very good" when properly used. The passions should be governed, not suppressed, directed, not annihilated. Virtue does not consist in the absence of passion, but in its regulation. In the highest and best development of a human being, all of the mental powers, as well as the vital functions, are harmonized, constituting "a sound mind in a sound body;" the domestic and social affections are governed by the moral sentiments, and these directed to their appropriate objects by the intellectual faculties. This is what should be understood by self-control.

OCCUPATION.

"Something to do" is as essential to health as are victuals and drink; and that something means some useful vocation; and as those pursuits in life which are most conducive to the general welfare, call into constant exercise the moral and intellectual powers, they cannot be otherwise than most conducive to health and longevity. It is true, that one-half the human race is overworked, and the other half do too little; but this is the fault of false or imperfect social arrangements and political institutions; and it is difficult to say who suffers the more, the drudges or the idlers. But a very great evil is the nature and kind of occupations, many of which are demoralizing and destructive. It were easy to show that more than one-half of all the labor of the toiling millions is worse than wasted. For examples, the liquor and tobacco traffics involve a financial loss to the people of the United States of not less than one thousand millions of dollars annually, to say nothing of the still worse consequences — the vices, crimes, pauperism, physical degeneracy, and mental disorder, that are ever their invariable accompaniments. Then, again, another sum, almost as large, is earned and expended for useless and enervating luxuries and meretricious adornments. Tea, coffee, sugar, candies, and confections, cost us a hundred millions of dollars annually; quack

What occupations are conducive to health? What vocations are ruinous to health and society?

medicines another hundred millions, and the ever-changing fashions of woman's dress, two or three hundred millions more. Were people to eat, drink, and dress for use and not for fashion, all the toil of accumulating these millions would be saved, and all would have ample time and means for moral and intellectual culture, and want and misery would hardly be known on the earth.

How could want and misery be best prevented?